MEMBERS

Volume 15 MARCH 1931 Number 3

BULLETIN
of the
American Association *of* Petroleum Geologists

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BULLETIN

of the

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

The Bulletin of The American Association of Petroleum Geologists is published by the Association on or about the 15th of each month. Editorial and publication office, 505 Tulsa Building, Tulsa, Oklahoma, Post Office Box 1852. Cable address, AAPGEOL.

The subscription price to non-members of the Association is $15.00 per year (separate numbers $1.50) prepaid to addresses in the United States. For addresses outside the United States, an additional charge of $0.40 is made on each subscription to cover extra wrapping and handling.

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BOX 1852

TULSA, OKLAHOMA

Entered as second-class matter at the Post Office of Tulsa, Okla., under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized March 9, 1923.

MID-WEST PRINTING CO., TULSA, OKLA., U. S. A.

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MARCH 1931

CRETACEOUS LIMESTONE AS PETROLEUM SOURCE ROCK IN NORTHWESTERN VENEZUELA[1]

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Maracaibo, Venezuela

ABSTRACT

Stratigraphic relations between the La Luna and Cogollo limestones of Cretaceous age in northwestern Venezuela are discussed. Both formations are somewhat petroliferous. The lithology, microscopic character, and occurrence of oil in the two formations are compared in detail. The conclusion is that oil in the La Luna limestone is indigenous, whereas that in the Cogollo has migrated into the rock from some other source. Analyses and simple tests of the La Luna rock indicate further the probability that it is, or has been, a source rock of petroleum. The specific source of the oil-generating material in the La Luna sediment is discussed from the viewpoint of what is known of the present composition of the rock and what may be inferred as to its original environment of deposition.

INTRODUCTION

Oil seeps and asphalt deposits occur on the eastern flank of the Sierra de Perijá, which divides Venezuela from Colombia and forms the western rim of the Maracaibo structural basin of northwestern Venezuela. Cretaceous limestones cropping out almost continuously along the mountain front are believed to be a source of part of this oil. Field and laboratory study of these limestones has revealed interesting relations between the occurrence of petroliferous and bituminous matter and the character of the enclosing rock, which may be of significance in connection with the general subject of source rocks and the origin of petroleum.

[1]Manuscript received, December 12, 1930.

[2]Geologist, Venezuela Gulf Oil Company, Apartado 234.

The following notes are made available for publication through the courtesy of E. S. Bleecker, chief geologist of the Venezuela Gulf Oil Company. An informal discussion of the subject matter with K. C. Heald, staff geologist of The Gulf Companies, has been of great value to the writer in the review and evaluation of the data collected.

It is hoped that if these notes prove of interest, more detailed tests may be made of the properties of the La Luna limestone as a possible source rock, where more suitable laboratory equipment and expert knowledge are available.

GENERAL STRATIGRAPHY

Sediments of Paleozoic, Mesozoic, and Cenozoic age are upfolded on the eastern front of the Perijá Mountains and exposed along the courses of many mountain streams which debouch on the lowlands of the Maracaibo Basin. The following discussion considers only the Cogollo and La Luna limestones of Cretaceous age, and adjacent formations. The general character of this part of the stratigraphic section in the northern part of the District of Perijá, State of Zulia, may be briefly summarized from top to bottom as follows.

1. *Lower Tertiary sediments.*—Barren or sparingly fossiliferous Tertiary sediments, chiefly sandstones, are in contact, but probably unconformably, with the Cretaceous rocks on the mountain front. Most of the principal oil seeps are noticed either in these sandstones or closely related to the Cretaceous-Tertiary contact. Other Tertiary sediments overlying these sandstones are not considered here.
2. *Colon shale.*—Upper Cretaceous. Variable in thickness and absent in most outcrop sections in northern Perijá, the Colon shale is a typically dark gray, foraminiferal shale. It has a thickness of several thousand feet in southern Perijá.
3. *La Luna formation.*—Cretaceous. This consists typically of dark carbonaceous limestone, resting conformably on the Cogollo limestone, and in contact with either the Colon shale or Tertiary sandstones above.
4. *Cogollo limestone.*—Lower Cretaceous. This is composed almost entirely of hard, light gray, massive limestone.
5. *Rio Negro conglomerate.*—Lower Cretaceous. Variable in development, in the southern part of the area this conglomerate has a thickness of several thousand feet, consisting typically of non-fossiliferous conglomerates and coarse sandstones.

Field and laboratory work on the Cretaceous limestones was initiated primarily with the hope of establishing a definite boundary between the Cogollo and La Luna limestones, which might aid correlation on the Perijá Mountain front. These formations were studied particu-

larly in the northern part of the District of Perijá along the valleys of Negro, Apon, Aponcito Mojado, Aponcito Seco, Macoita, Piche, Cuiba, Tinacoa, and Cogollo rivers. Acknowledgment is due J. T. Scopes, of the Venezuela Gulf Oil Company, and others who aided in the collection of outcrop samples. A particularly interesting set of samples of both the La Luna and Cogollo limestones was also obtained from the Vemor well of the Venezuelan Atlantic Refining Company in the northeastern part of the District of Mara, State of Zulia. Laboratory work was done in the geological laboratory of the Venezuela Gulf Oil Company in Maracaibo.

The results of the work show that two distinct types of Cretaceous limestone, a La Luna type and a Cogollo type, exist in this part of the country. These can be clearly differentiated, but in most places no definite line of formation contact can be drawn because of interbedding of the two types. However, division into two formations is believed to be justified because the Cogollo type is decidedly predominant in the lower part of the section, and the La Luna type generally prevails in the upper part.

GENERAL LITHOLOGIC CHARACTER OF LA LUNA AND COGOLLO LIMESTONES

The La Luna limestone in typical development is dark gray to black. The formation is characteristically more thin-bedded than the underlying Cogollo limestone and is in many places finely laminated. It is particularly characterized by black, ellipsoidal, limestone concretions ranging from a few inches to several feet in diameter. Many of these concretions, when broken, show well preserved mollusk shells as nuclei. Megascopic fossils are in general rare, although a profusion of fish scales is characteristic of parts of the formation. When freshly broken, some of the limestone has a strong petroleum odor. Black chert is common as seams and nodules. The total stratigraphic thickness of the formation may be as much as 2,000 feet in this area, but exposed thicknesses are markedly different because of faulting.

The Cogollo limestone is typically gray or light gray limestone. It is harder, more massive in bedding, and more resistant to weathering than the La Luna. Molluscan fossils are common, and in places the rock is almost entirely composed of poorly preserved *Exogyra*. Fossil shell material is generally recrystallized, and the whole formation is much more coarsely crystalline than the La Luna limestone. Gray chert is common. The total stratigraphic thickness is probably approximately 1,500 feet.

MICROSCOPIC CHARACTER OF LA LUNA AND COGOLLO LIMESTONES

Microscopic examination of many samples shows that typical La Luna limestone can be easily differentiated from typical Cogollo limestone in thin section. Under the microscope the black La Luna rock is seen to be composed almost entirely of tests of small pelagic *Foraminifera* (*Globigerina*, *Globorotalia*, *Globotruncana*, *Guembellina*, et cetera). The test cavities are generally filled with clear crystalline calcite, and the surrounding matrix is composed chiefly of dark gray or black carbonaceous and bituminous matter. Most of the rock is uniformly petroliferous. Large fossils are almost completely absent, and there is little or no coarsely crystalline calcite. There is very little sand impurity. The slides are uniformly dark in color.

Thin sections of typical Cogollo limestone show that it is entirely lacking in the pelagic foraminiferal remains which are the major constituent of the La Luna limestone. However, there is a profusion of large fossils. Mollusks, echinoid fragments, and bryozoans are common. *Foraminifera* are limited chiefly to a few specimens of *Orbitolina texana* and a large unidentified rotaliform specimen. Some beds are seemingly composed chiefly of calcareous algae, and algal remains are characteristic of the formation in general. Many thin sections show a peculiar structure of round, elongate pellets of yellowish brown, impure limestone. This pellet limestone is generally phosphatic. The pellets probably represent fossil excrement of bottom-living invertebrates. The Cogollo limestone is sandy and glauconitic in many places. Some of it is coarsely crystalline. It is commonly petroliferous, the oil being noticed as dark lines following fractures in the rock. The slides are uniformly light in color.

Microphotographs of thin sections of typical La Luna and Cogollo limestone specimens shown in Figures 1-8 were taken by E. B. Dana, of the Venezuela Gulf Oil Company, and the writer, using a Leitz petrographic microscope and transmitted light.

Figures 1-4 show thin sections of typical La Luna limestone from several localities. The profusion of small *Foraminifera*, especially *Globigerina*, is immediately apparent. The light parts of the photographs are clear calcite, and the dark groundmass represents carbonaceous and bituminous organic matter and clay substance. Figure 4 is of particular interest as a section at right angles to the bedding. The close resemblance between sections of La Luna limestone from different localities is noteworthy.

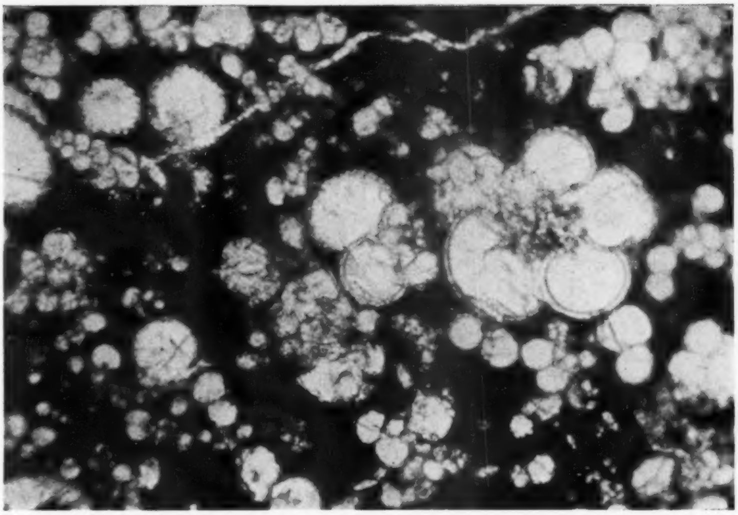

FIG. 1.—Thin section of La Luna limestone from Rio Aponcito Seco, District of Perijá. Calcite-filled tests of *Globigerina* and *Guembellina* in dark matrix of carbonaceous-bituminous matter. Sample No. Ap.S-4. Magnification: × 77.

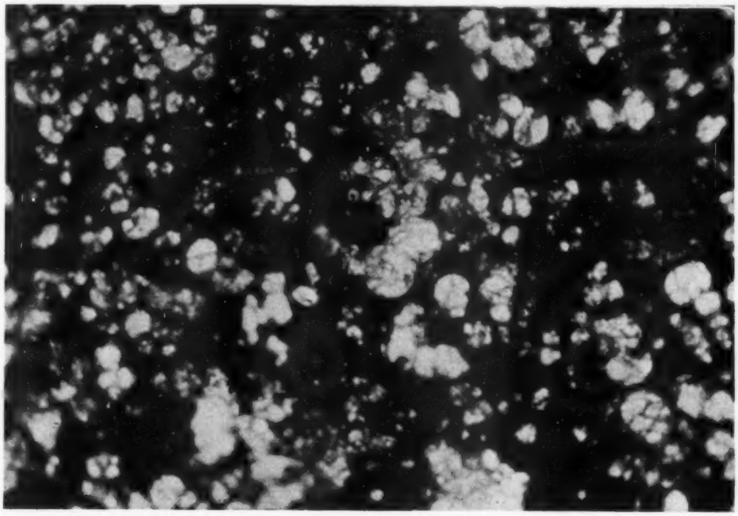

FIG. 2.—Thin section of La Luna limestone from Rio Negro, District of Perijá. *Globigerina* and other pelagic *Foraminifera* in dark carbonaceous-bituminous matrix. Sample No. N-7(C). Magnification: × 77.

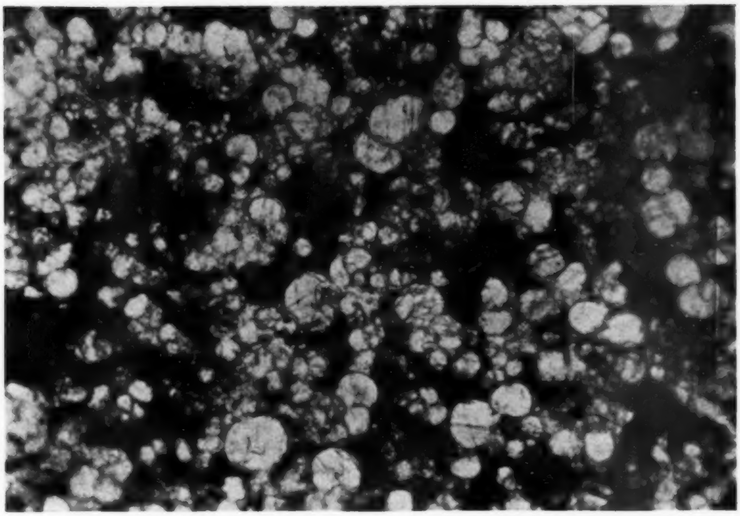

Fig. 3.—Thin section of La Luna limestone from core sample at 4,409 feet in Vemor No. 1, District of Mara. Plentiful *Globigerina* and other pelagic *Foraminifera* in dark carbonaceous-bituminous matrix. Magnification: × 77.

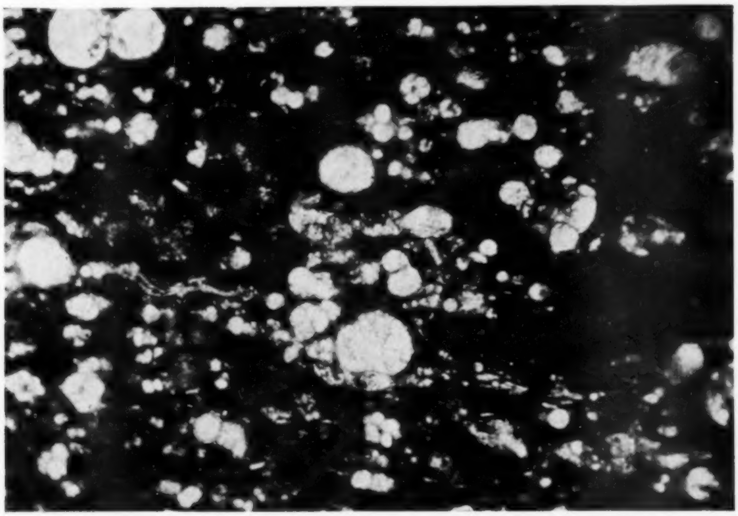

Fig. 4.—Thin section of La Luna limestone from Rio Negro, District of Perijá. Section is cut at right angles to bedding. Calcite-filled tests of *Globigerina* and *Guembellina* are shown as white areas contrasting with dark carbonaceous-bituminous matrix. Sample No. N-6(C). Magnification: × 77.

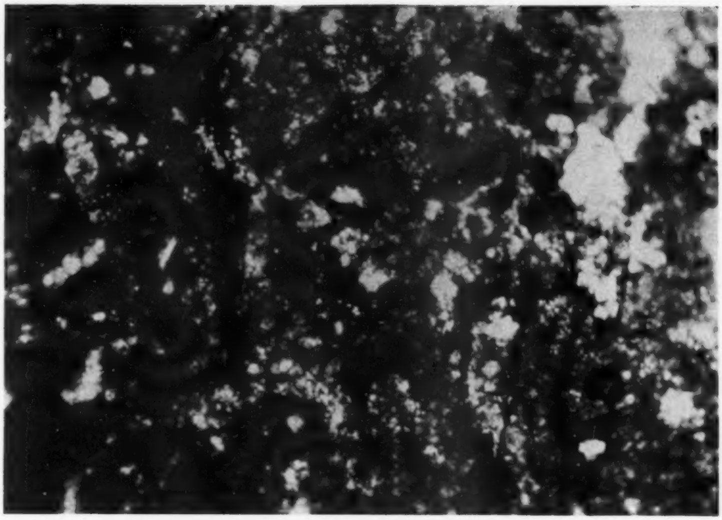

Fig. 5.—Thin section of Cogollo limestone from Rio Cogollo, District of Perijá. Dark zigzag line across center of picture is stylolitic fracture filled with oil. Sample No. Cog-19. Magnification: × 77.

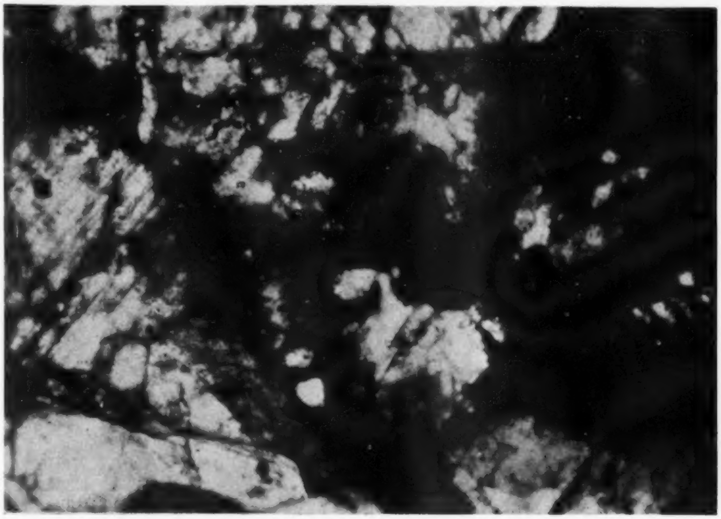

Fig. 6.—Thin section of Cogollo limestone from Rio Cogollo, District of Perijá, showing heavy oil staining (dark) along fractures in coarsely crystalline limestone. Sample No. Cog-6(9). Magnification: × 77.

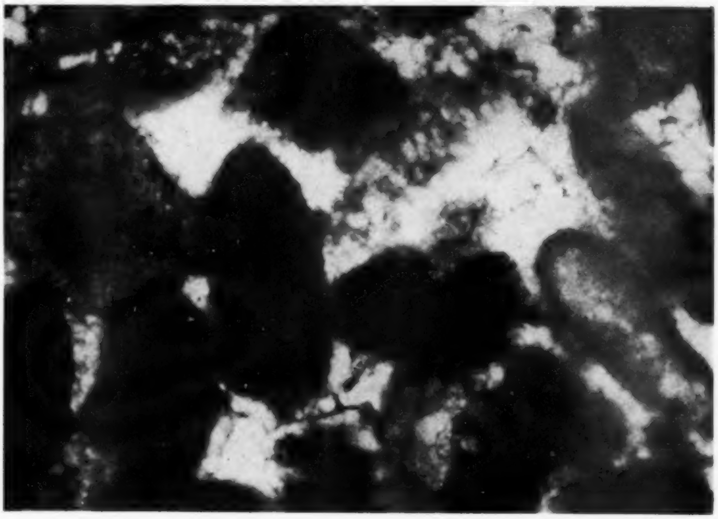

FIG. 7.—Thin section of Cogollo limestone from core at 4,706 feet in Vemor well, District of Mara, showing typical pellet structure; also calcareous algae at extreme left. Magnification: × 77.

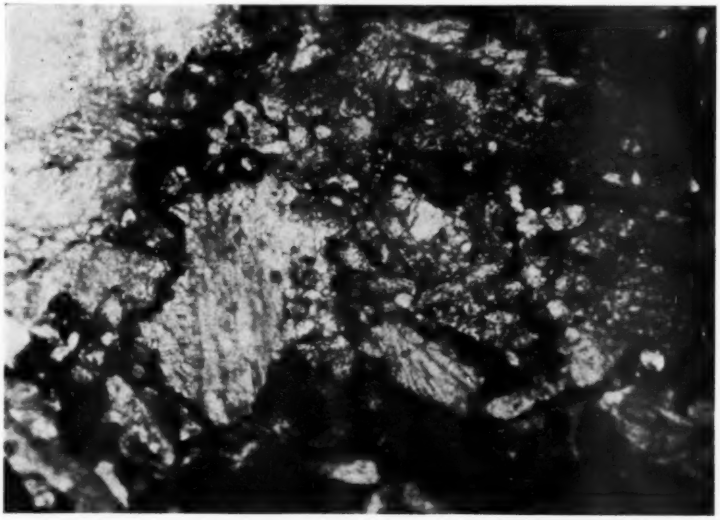

FIG. 8.—Thin section of non-foraminiferal gray limestone interbedded with typical dark foraminiferal La Luna limestone on Rio Cogollo, District of Perijá. Section clearly shows that oil staining (dark) is chiefly confined to fractures in rock. Sample No. Cog-6(1). Magnification: × 77.

Microphotographs of thin sections of Cogollo limestone are shown in Figures 5-7. The lack of small foraminifers and carbonaceous matter and the relatively coarsely crystalline character of the Cogollo limestone as compared with the La Luna are evident. Figure 7 shows the peculiar pellet structure previously mentioned. This pellet structure has been noticed as a characteristic phase of the Cogollo limestone in the Vemor, Rio Cogollo, Rio Negro, Aponcito Seco, and other sections. Figure 8 shows typical Cogollo limestone interbedded with typical La Luna limestones in the upper part of the La Luna formation.

ENVIRONMENT OF DEPOSITION OF LA LUNA AND COGOLLO LIMESTONES

The Cogollo and La Luna limestone types obviously represent two very different facies of sedimentation. It has been widely believed that the change from Cogollo to La Luna deposition marked a change from deep-water to near-shore or shallow-water environment. Possibly opposed to this commonly accepted idea are the facts that the Cogollo limestone lacks the remains of pelagic life, contains many mollusks but few foraminifers, and in many places is sandy and glauconitic. The La Luna, however, contains very few mollusks and is composed almost entirely of pelagic foraminifers. The La Luna is an impure limestone, but analyses show that much of the impurity is carbonaceous and bituminous matter rather than inorganic sediment. The rock is very rarely sandy and such clastic sediment as there is consists of very fine clay. At the time of deposition La Luna sediment must have existed as *Globigerina* ooze.

Life in La Luna seas seems to have been almost exclusively planktonic. During La Luna time the bottom waters evidently developed a "toxicity" because of lack of circulation, due perhaps to depth, perhaps to physiography of the ocean floor, which rendered them almost uninhabitable by marine benthonic animal life. Remains of the abundant plankton at the surface accumulated undisturbed by the action of the bottom-living scavengers that must have existed in the Cogollo sea. Moreover, this toxicity and lack of oxygen probably prevented rapid bacterial decay and permitted partial preservation of the soft organic matter of the pelagic life forms which settled to the bottom. Whatever the cause of the condition outlined, it was widespread and must have existed almost continuously in this area for a long time to permit the deposition of the great thickness of essentially homogeneous sediment included in the La Luna formation.

BASIS FOR FORMATION DIVISION

Unfortunately for stratigraphic correlation and the definition of formations, a few beds of seemingly typical black carbonaceous foraminiferal La Luna limestone are intercalated within the Cogollo limestone, and similarly thin beds of typical light gray non-foraminiferal Cogollo-like limestone also occur within the dominantly La Luna part of the section (Fig. 8). Such interbedding of types is especially noticeable in a transition zone between the major developments of the two limestones and obviously represents an alternation of Cogollo and La Luna environments. There is probably no time break between the two formations. The La Luna has been called Upper Cretaceous and the Cogollo Lower Cretaceous, but if this difference in age exists, it is probably represented only by a very gradual evolutionary change in fauna. However, sharp differences due to the change in environment are naturally to be expected.

For purposes of correlation the contact between the Cogollo and La Luna formations is best placed at the base of the predominantly carbonaceous, foraminiferal limestone section. This leaves minor beds of La Luna-like limestone within the upper part of the Cogollo formation in many areas. However, it must be recognized that the division between these formations does not indicate a complete and permanent change in the character of sediments, but indicates only a place in a zone of alternating facies where the La Luna type of limestone begins to be predominant. The formation boundary is thus a more or less arbitrarily chosen point in each different section.

OCCURRENCE OF PETROLEUM IN LA LUNA AND COGOLLO LIMESTONES

Approximately thirty samples of La Luna limestone from various localities were washed with chloroform in the laboratory and in every sample at least a weak coloration was obtained. Thin-section study shows that the calcareous foraminiferal tests rest in a dark brown-to-black impalpable matrix (Figs. 1-4), and treatment of sections under the microscope shows that the chloroform colorations obtained come from petroleum uniformly diffused throughout this dark matrix.

The Cogollo limestone, also, is in many places petroliferous, and many samples yield a strong chloroform coloration. However, microscopic examination shows that the oil occurs only in fractures and microfractures and is not uniformly diffused throughout the rock (Figs. 5, 6, and 8). A single exception must be made of the thin films of oil found

surrounding some of the skeletons of calcareous algae. Oil in the Cogollo limestone is generally more plentiful in the upper part of the formation than in the lower.

The Rio Negro conglomerate, underlying the Cogollo formation, does not, so far as the writer knows, show any traces of oil. However, the Tertiary sandstones which rest upon the La Luna limestone (and the Colon shale where present) are in places impregnated with oil, and many of the large seepages of northern Perijá come from these sandstones or from the contact between them and the Cretaceous section. These rocks, however, are almost devoid of fossils or organic matter other than free petroleum, which may be completely removed with solvents.

The inference suggested by the manner of petroleum occurrence in the several formations is that the oil of the La Luna limestone is indigenous, whereas that of the other formations is due to migration from another source, possibly or even probably the La Luna formation itself. The petroleum of the La Luna limestone is uniformly diffused through the rock, although the formation is relatively dense and impermeable and is in contact with the dense Cogollo limestone below and the thick Tertiary sandstone above, neither of which possesses any of the ordinarily recognized characteristics of source rocks. Other petroliferous formations are known higher in the Tertiary section, but it seems improbable that oil migrating from these could so thoroughly permeate a dense limestone formation of the magnitude of the La Luna.

ANALYSIS OF LA LUNA LIMESTONE

Microscopic examination shows that the typical La Luna rock is composed almost entirely of (1) calcareous tests of pelagic foraminifers and (2) dark brown-to-black, translucent-to-opaque, impalpable matter. Recognizable calcareous foraminiferal remains in places constitute as much as 90 per cent of the rock. As previously mentioned, the petroliferous character of the dark matrix was demonstrated by chloroform extraction. Only a small part of this dark matrix, however, was soluble in the ordinary petroleum solvents. In an attempt to secure more definite information on the character of the insoluble part of the matrix, approximate analyses were made of specimens of La Luna limestone. This work was performed by Anton Bopp, of the geological laboratory. The results of these analyses follow.

ANALYSES OF LA LUNA LIMESTONE

Locality	*Sample*	*I*	*II*	*III*	*IV*	*V*
Rio Negro	6 (A)	0.20	83.49	3.86	.....	12.44
Cano Mene	N-44	0.88	43.61	11.87	0.36	43.28
Rio Cogollo	6 (5)	1.46	66.51	13.60	3.77	14.66
Rio Aponcito Mejado	Ap.M-4	1.59	42.33	10.57	2.32	43.19
Rio Aponcito Seco	Ap.S-4	0.63	94.64	0.44	.....	4.29

I. Percentage of free petroleum. Approximately determined as the percentage (by weight) of the powdered rock substance soluble in carbon tetrachloride.

II. Percentage of calcium carbonate. Determined approximately as the percentage of rock substance soluble in dilute hydrochloric acid. This figure may be somewhat higher than the true percentage of calcium carbonate because of solution of other substances in the rock. However, as the samples seem to be almost free from iron oxides, the figure is believed to be substantially correct. It probably also very nearly represents the total percentage of carbonates, as dolomite has not been noticed anywhere in the formation.

III. Percentage of organic matter insoluble in petroleum solvents. Determined approximately by ignition of residue remaining after carbon-tetrachloride and hydrochloric-acid treatment.

IV. Percentage of pyrite. Approximately determined by nitric-acid treatment of part of residue remaining after carbon-tetrachloride and hydrochloric-acid treatment.

V. Percentage of inorganic sediment. Determined by difference.

The percentage of calcium carbonate is undoubtedly due almost entirely to foraminiferal tests and their fillings, the microscopic examination showing little calcite in the matrix material. Small fragments of the rock generally retain their form perfectly after solution of all calcium carbonate with acid. The small percentage, by weight, of petroleum is noteworthy because in each sample at least a weak chloroform coloration was obtained. The residue of inorganic sediment remaining after ignition was examined microscopically and found to consist of microcrystalline insoluble clay substance with minute granules of iron oxide and a profusion of very small, moderately birefringent, colorless crystals of refractive index less than quartz and with parallel extinction and positive elongation. The absence of all sand and the scarcity of grains of even silt grade are noteworthy. In a few samples the siliceous tests of radiolarians were somewhat common.

Little was learned about the nature of the non-soluble organic matter either from the approximate analysis or from microscopic examination. It seems to exist as a brown to brownish black, translucent, amorphous substance mixed with the inorganic clay and in most places surrounding the calcite-filled foraminiferal tests, but in some beds apparently forming a part of the filling itself. Some information on the character of this organic matter was gained from some crude distillation experiments conducted by Bopp.

Chloroform colorations were obtained from several freshly pulverized samples of La Luna limestone which had been passed through an

80-mesh sieve. These were rated according to a standard scale of 5 points in which 1 is the weakest clearly visible coloration and 5 is almost opaque black. All petroleum was removed from the samples by repeated washing in chloroform and carbon tetrachloride. A small amount of each prepared sample was placed in a long piece of glass tubing closed at one end. The rock powder was heated moderately, and the gases driven off were allowed to condense on the walls of the tube. Both rock powder and distillate were again treated with chloroform, and the degree of coloration was noted according to the same standard. In every sample chloroform colorations were again obtained after heating, although all soluble petroleum had previously been removed and some of the second tests were much stronger than the first. Data on several samples are given.

Sample	*Chloroform Coloration*	
	Before Heating	*After Extraction and Heating*
Rio Cogollo, Cog-6(5)	4-5	5
Cano Mene N-44	1-2	4-5
Cano Mene N-45	2	1-2
Ap.M-6	3-4	2-3
Ap.M-4	5	3-4
Ap.S-4	5	2-3
Vemor, 4,180 feet	5	4-5
Vemor, 4,419 feet	3-4	1-2
Vemor, 4,408 feet	5	3

It is regretted that facilities for thorough distillation tests were not available. The results of the tests performed indicate that the solid, organic matter of the La Luna is partly bituminous, insoluble in chloroform, but partly convertible into petroleum by heating.

REVIEW OF EVIDENCE FOR CONSIDERING LA LUNA LIMESTONE A PETROLEUM SOURCE ROCK

1. Petroleum occurs in small quantity in the La Luna and Cogollo limestones and in large seepages at the Cretaceous-Tertiary contact and in the overlying Tertiary sandstones. This petroleum is diffused uniformly through the dark carbonaceous-bituminous groundmass of the La Luna limestone, but in the underlying Cogollo limestone is chiefly confined to fractures and micro-fractures, and in the immediately overlying Tertiary beds is chiefly confined to sandstones.

2. The La Luna limestone contains much fossil organic matter. The Cogollo limestone and the Tertiary sandstone lack organic matter other than free petroleum, most of which may be removed by the common oil solvents. Only a very small part of the organic matter of the La Luna formation can be removed by these solvents.

3. Some petroleum can be generated from the solid organic matter of the La Luna limestone by heating.

4. Both the Cogollo limestone and the Tertiary sandstones are generally increasingly petroliferous in those parts of the formations nearest the La Luna limestone (or Colon shale where present).

5. The La Luna is a relatively dense, impermeable formation and is in contact with the dense Cogollo limestone below and (where the Colon shale is missing) with the thick Tertiary sandstones above. Neither of these has the characteristics of a source rock and it is difficult to conceive of a dense formation like the La Luna being so completely permeated by oil from a more distant source.

6. A few beds of La Luna type limestone occur interbedded with the typical Cogollo limestone. These stray beds definitely maintain their La Luna characteristics in regard to petroleum content. Similarly Cogollo-like limestone beds in the La Luna formation show oil only in fractures.

The foregoing facts are believed to constitute very strong evidence, if not actual proof, that the La Luna limestone is a source rock of petroleum.

ORIGIN OF OIL IN LA LUNA LIMESTONE

The La Luna and Cogollo limestones, both of Cretaceous age, are in conformable contact. The La Luna seems to be a petroleum source rock, whereas most of the petroleum in the Cogollo is due to migration from some other source. The difference between the two limestones as producers of petroleum (whether past or present) may be assumed to be a result of differences either in the sediments from which they were formed or in environment of deposition, as their subsequent histories must have been essentially identical. Factors of at least local significance with respect to limiting conditions for the formation of petroleum source beds might be deduced from a comparison of the origins of these two limestones if they could be interpreted correctly from the present composition and structure. Certain outstanding differences in the lithology of the typical La Luna and Cogollo rocks have already been mentioned, and these suggest some tentative conclusions concerning their origin.

Both La Luna and Cogollo limestones are fossiliferous. The La Luna is composed chiefly of the tests of pelagic foraminifers. Large fossils are rare. The Cogollo, however, is almost entirely lacking in foraminifers but contains many mollusks, algae, et cetera. The favorable environment for the formation of petroleum thus permitted (1) the existence of abundant planktonic life and (2) its ultimate preservation as bottom sediment. The Cogollo environment was undoubtedly favorable to molluscan life and the preservation of molluscan shells. Either foraminiferal plankton was not present in the Cogollo seas or its accumulation as sediment was prevented by the action of bottom-living scavengers or other causes. The critical factor to be deduced in regard to the origin of oil is probably not the presence of abundant plankton in the sea waters, but the presence of conditions of bottom environment which permit its preservation.

The La Luna formation contains a profusion of carbonaceous, bituminous, organic matter. The Cogollo contains almost none. This organic matter contains some free petroleum and preliminary tests indicate that additional oil may be generated from it by heating. It seems probable that it is either source material which under the proper natural conditions is still capable of generating oil or it is the residue after the process has been completed. The presence of solid organic matter is generally a requisite of sediments which have been commonly considered to be or to have been source rocks. The conditions which cause the La Luna to contain much organic matter and the Cogollo to be almost devoid of it are undoubtedly of great significance. The La Luna rock would seem to have all the qualities of a consolidated *Globigerina* ooze were it not for the profusion of organic matter. Most modern *Globigerina* oozes which have been described are light in color and have little organic matter. However, no evidence of land-derived organic matter has been identified in the rock; furthermore, observations on the distribution of recent *Globigerina* muds indicate that they are not commonly formed in ocean areas where much land-derived organic matter is being deposited. The extreme scarcity of skeletons of bottom-living animals eliminates them as a source of the organic matter. Thus, the conclusion is that the organic matter was derived from planktonic life. The reason for its profusion in the La Luna *Globigerina* deposits and its scarcity in present-day deposits of the same nature must be either a difference in the character of the life forms in the plankton or special bottom conditions which permitted the preservation of organic matter which is lost in the known deposits of the present day. As stated previously, it seems very

possible that the same toxic condition of the bottom waters which was postulated as an explanation of the scarcity of benthonic forms may also have been a factor in the preservation of planktonic, organic matter which reached the bottom.

It is assumed, therefore, that the solid organic matter of the La Luna limestone is petroleum source material, or the residue therefrom, and that this organic matter was derived chiefly from planktonic life which settled to a bottom environment particularly suitable for its preservation. A determination of the specific source material within the plankton would, of course, be of the greatest importance, but it is exceedingly difficult. Pelagic foraminifers are almost the only recognizable forms of life within the limestone, and the identifiable tests of these animals in many places constitute as much as 90 per cent of the rock. The conclusion seems justified that the origin of oil in the La Luna rock is connected either directly with these foraminifers themselves or, at least, with conditions particularly favorable to their existence and the subsequent preservation of their tests.

In considering the possibility of a direct connection between foraminifers and oil genesis, the question arises as to whether, and if so, under what conditions, tests of pelagic foraminifers reach the bottom of the sea with an appreciable amount of organic matter remaining in them. Present-day *Globigerina* oozes contain little organic matter, although, as previously stated, this may be a result of bottom conditions unfavorable for its preservation rather than the primary lack of such material. Another difficulty with the foraminiferal hypothesis is that most, although not all, thin sections of the limestone show the foraminiferal tests completely filled with calcite and seemingly free from carbonaceous matter, which is confined to the surrounding matrix. However, if not foraminifers, what constituent of the plankton is the source? No other recognizable traces of planktonic life have been noticed with the exception of radiolarian tests, which are only locally common. As a remaining alternative, the source may be ascribed to some form of life which has left no identifiable fossil structures. Non-calcareous algae of various sorts and the soft larval forms of higher invertebrates constitute an important part of the plankton. Much of this life might leave no clearly recognizable remains, and it is conceivable that such life forms may be chiefly responsible for the matrix of organic matter surrounding the foraminiferal tests.

DISCUSSION

R. A. Liddle, Fort Worth, Texas: The La Luna formation, named from Rio La Luna in the western part of the District of Perijá, State of Zulia, is difficult

to separate from the overlying Colon shale: it is doubtless the basal part of that predominantly shale body, and it grades downward into the Cogollo limestone. In the Sierra de Perijá, the basal part of the formation to which I have referred as the Colon shale, in *The Geology of Venezuela and Trinidad*,[1] can be separated fairly well from the rest of the deposit, but I doubt if it can be done satisfactorily in many other parts of the country; however, the area in which it can be differentiated is of sufficient size to justify a formational name.

Mr. Hedberg refers, without qualification, to the ellipsoidal bodies in the La Luna limestone as concretionary. Although there are many concretions, there are also many lenticular limestone masses, extremely variable in size, which show no evidence of concentric or concretionary structure. I found many diminutive ammonites forming a nucleus for these ellipsoidal bodies, which also contain fish scales in profusion, molluscan remains, and some complete skeletons of fishes. Not only do most of the limestones have a strong petroleum odor, but many body cavities, chiefly of cephalopods, are filled with asphaltic oil. I noticed considerable replacement of fossils, especially ammonites, by calcite.

Along the mountain front of the Sierra de Perijá, it is difficult to measure a section on account of faulting, but I doubt if there are 2,000 feet of the material which Mr. Hedberg places in the La Luna formation. It is interesting to notice that, whereas the ellipsoidal bodies of limestone are very fossiliferous, the remainder of the limestone is nearly barren of megascopic life. This probably accounts for the absence of calcite noted by Mr. Hedberg, for this mineral ordinarily occurs in the La Luna and the Cogollo as replacement of fossils or deposition in cavities and fractures.

Not only in western Venezuela, but in all parts of the country where I noticed oil or asphaltic material in the Cogollo limestone, it was found in joints or fractures, the remainder of the rock being barren. This suggests, as Mr. Hedberg mentions, that the oil has migrated into the formation along lines of breaking.

It might have been well if Mr. Hedberg had outlined the entire Cretaceous sedimentary cycle of northwestern Venezuela in his discussion of the environment existing during the deposition of the La Luna and Cogollo limestones, to give a clearer picture.

The basal part of his Rio Negro conglomerate is conglomerate and conglomeratic sandstone separated by thin shale layers; these beds grade upward into normal sandstones and sandy shales in which occur a few dense limestone ledges. On the Rio Negro conglomerate there rests, with seeming conformity, the massive Cogollo limestone, which changes upward into his La Luna limestone. In the upper part of the La Luna formation there is an increase in shale content, which makes it difficult to distinguish from the conformably overlying Colon shale. Unconformably on different levels in the Colon shale, or even on the La Luna limestone, depending on the amount of local unconformity, are Eocene sandstones. Locally in the basal part of the Eocene are sporadic limestones of oyster-reef character, which grade upward into sandy shales and lignitic shales. From casual observation one would be led to surmise that shallow water existed where the Rio Negro conglomerates were deposited, the river mouths or estuaries becoming deeper as the shales and occasional lime-

[1] Fort Worth, Texas (1929).

stone beds of the upper part of the formation were laid down; however, this sinking could not have been extreme, as is evidenced by the thick ledges of oyster remains in the lower part of the Cogollo. The upper part of the Cogollo has few oyster remains, and the thick, fairly pure limestone ledges suggest deeper, and without doubt clearer, water. I had thought that the maximum depth of the Cretaceous seas of northwestern Venezuela, or, so far as that is concerned, of all Venezuela, was reached during the accumulation of the thick beds of dense limestone of middle Cretaceous age, and that the Colon shale (as I interpreted it), was laid down on an emerging continental shelf. From the ammonites and pelecypods in the ellipsoidal limestone bodies, principally in the lower part of the Colon formation (the La Luna of Hedberg and others), I concluded that the shales and limestones were not deep-sea deposits (accumulation of deep-sea oozes), but continental-shelf shales in which some foraminiferal remains occurred. However, I was not aware at that time of the profuse micro-fauna which Hedberg thinks indicative of deep-sea muds. I am inclined to feel that the *Foraminifera* in the La Luna do not indicate that, "At the time of deposition, La Luna sediments must have existed as *Globigerina* ooze," but that these microscopic organisms, together with molluscan remains, accumulated in fairly shallow water, under conditions favorable for their preservation. Granting that the La Luna limestone is prolific in *Foraminifera*, one must explain their occurrence with a plentiful and varied molluscan fauna, which actually is found in the La Luna at its type locality on Rio La Luna. Uplift and shallow-water conditions following La Luna or Colon time are suggested by the erosional top of the Colon formation, and by the shallow-water character of the lower Eocene. It is possible that some of the difference in lithologic character between the Cogollo and La Luna may be due to a different source of the material, and a changing clarity of water in the seas in which the formations were laid down.

Mr. Hedberg's position that the La Luna formation is a source horizon for petroleum is, I believe, well taken. I think all factors point conclusively to its being an ideal source rock. It has all the necessary constituents, and I know of no reason for suggesting that the oil permeating it has come from an outside source; in fact, I think that all of the Cretaceous above the Cogollo in the northern part of the District of Perijá is typical source material of oil. The physical character of the Cogollo indicates that it was deposited in much clearer water than was the La Luna; and possibly this has a direct relation to the amount of organic matter which was preserved long enough to be converted into oil and gas.

My opinion is that the relatively clear-water conditions which existed during the deposition of the Cogollo limestone were not conducive to the retention of organic matter, which originally was much less plentiful in the Cogollo than in the La Luna. But it should be remembered that seemingly indigenous oil and gas are found in other parts of the world in limestones which to all appearances are less favorable sources than is the Cogollo. A striking example is the oil and gas in the middle Permian limestone in the western part of the state of Texas, below a great thickness of salt, red shale, and anhydrite, and several hundred feet above any of the horizons commonly associated with the generation of petroleum.

EAST HACKBERRY SALT DOME, CAMERON PARISH, LOUISIANA[1]

A. J. BAUERNSCHMIDT, JR.[2]
Sulphur, Louisiana

ABSTRACT

The East Hackberry salt dome, Cameron Parish, Louisiana, was discovered in 1926 by means of the seismograph. It is a knob on a large salt mass which includes West Hackberry. Most of the oil is produced from Miocene sands which are approximately 3,900 feet in depth, but the producing sands overlying the cap rock are probably Pliocene. The oil (18°-24° Bé. gravity) occurs in a narrow zone on the south flank of the dome and in a small area overlying the cap. The initial production of the wells ranges from 25 to 3,000 barrels of oil per day, and from 1927 to the end of 1930 a little more than 2,000,000 barrels of oil has been produced from thirty-five wells.

LOCATION

The East Hackberry salt dome is located in Sections 13, 24, 36, 37, and 46, T. 12 S., R. 10 W., Cameron Parish, Louisiana. It is approximately 20 miles south of the town of Sulphur and 20 miles inland from the Gulf Coast; it may be reached by road from Sulphur, and by water from Calcasieu Lake and Kelso Bayou (Figs. 1 and 2).

DISCOVERY AND DEVELOPMENT

The dome was discovered in 1926 by the Calcasieu Oil Company while making a seismographic survey of surrounding territory.

The first test well, Caldwell No. 1, was drilled jointly by the Calcasieu Oil Company, Inc., the Magnolia Petroleum Company, and The Union Sulphur Company. This well was drilled to a total depth of 4,016 feet, where it blew out, caught fire, and finally cratered. Caldwell No. 2, the second test, and the first producing well, on November 7, 1927, had an initial flow of 800 barrels of 22° Bé. gravity oil from a sand at a depth of 3,973 feet. From this well the field gradually spread east and west. The westward development was soon stopped after several wells were abandoned in heaving shale and salt; but development continued

[1]Manuscript received, December 5, 1930. Published by permission of W. R. Keever, president, Calcasieu Oil Company, Inc.

[2]Chief geologist, The Union Sulphur Company.

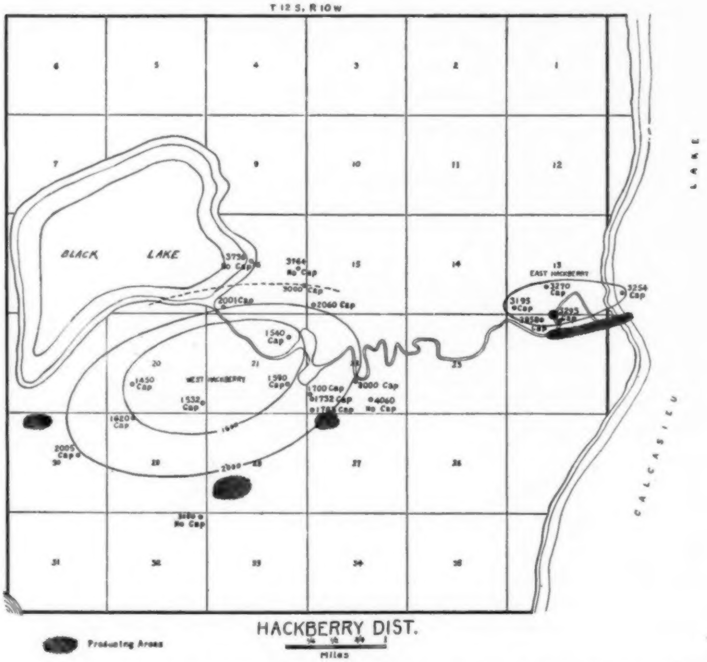

FIG. 1.—Map of Hackberry district, showing depth in feet below surface to top of cap rock.

eastward in a narrow strip. The farthest east producing well is The Texas Company's State No. B-3, located in Calcasieu Lake.

The deepest well drilled on the south flank was Caldwell No. 5 in Section 38. The only showing of oil in this well was in a conglomerate calcareous rock at 6,792 feet. The well was abandoned at 6,998 feet in heaving shale.

In March, 1930, a location (Watkins No. 17) was made on a seismographic "high" on top of the dome. The initial flow of the well on April 7, 1930, was 1,288 barrels of 22° Bé. gravity oil from a sand at 2,707 feet. This discovery opened a shallow productive zone overlying the cap rock; earlier production was from sands at a depth of approximately 3,900 feet on the south flank.

Eighty wells have been completed, of which 40 were dry holes and 40 were producing wells, with a total production of a little more than

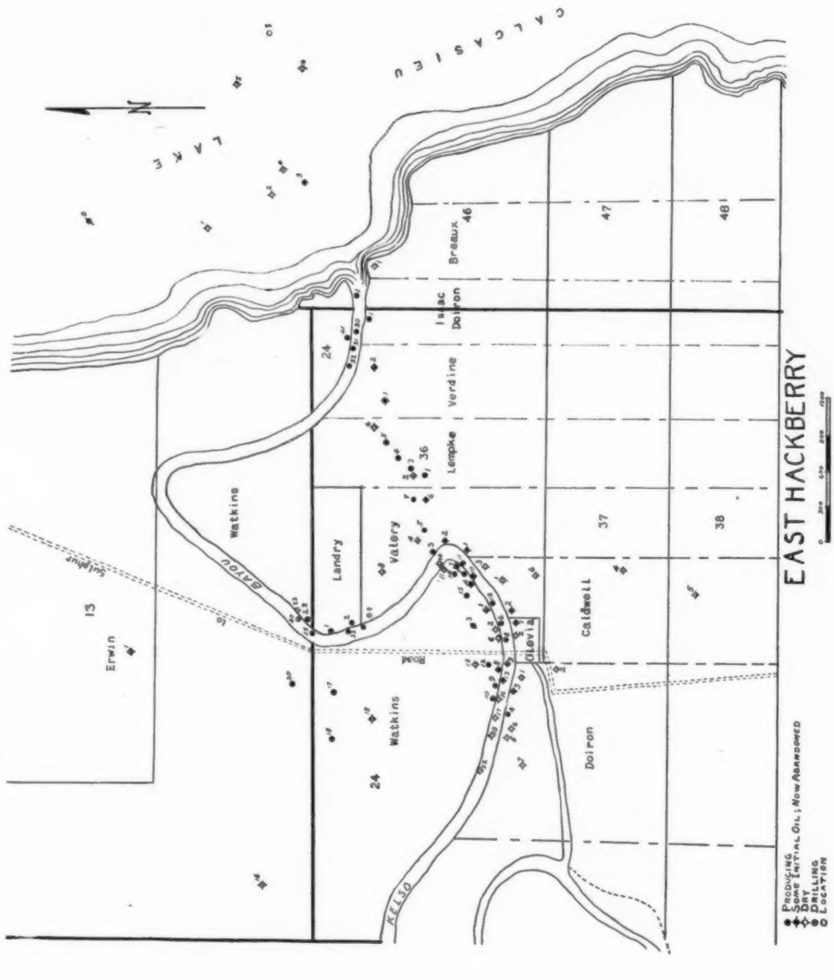

FIG. 2.—Map of East Hackberry, showing location of wells.

TABLE I

LIST OF WELLS DRILLED AT EAST HACKBERRY

Well		Date Completed (Month, Day, Year)	Total Depth (in Feet)	Top of Oil Sand (in Feet)	Initial Production (in Barrels)	Producing	Remarks Gravity References, Bé.
CALCASIEU OIL COMPANY, INC.							
Caldwell	1	8/ 7/27	4,016			No	Cratered; abandoned
	2	11/ 1/27	3,996	3,973	984	No	Gravity 22; abandoned at 4,214 feet
	3	4/13/28	4,010	4,000	600	No	Gravity 22; abandoned in salt at 4,187 feet
	4	12/10/29	5,764		Dry	No	Abandoned in heaving shale
	5	5/29/30	6,998		Dry	No	Abandoned in heaving shale
	6	9/22/30	4,722		Dry	No	Abandoned in heaving shale
Doiron	1	4/20/28	5,154		Dry	No	Abandoned
	2	6/24/28	4,859		Dry	No	Abandoned in heaving shale
	3	8/15/28	4,017	4,012	32	No	Abandoned
	4	10/10/28	3,890	3,881	790	Yes	Gravity 22
	5	4/ 2/29	3,707		Dry	No	Abandoned
	6	5/27/29	4,050		Dry	No	Abandoned in salt
	7	10/ 4/29	4,002		Dry	No	Abandoned in salt
Olevia	1	1/18/28	3,997	3,997	1,700	No	Gravity 22; abandoned
	2	7/18/28	4,434		Dry	No	Abandoned in heaving shale
Valery	1	6/30/28	3,965	3,953	800	No	Gravity 22; abandoned
	2	8/22/28	4,148	4,138	1,000	No	Gravity 22; abandoned
	3	10/18/28	3,808	3,789	1,300	Yes	Gravity 22
	4	11/21/28	3,760		Dry	No	Abandoned in salt
	5	12/21/28	3,876	3,860	1,500	Yes	Gravity 22.8
	6	4/11/29	3,935	3,927	100	No	Gravity 23
	7	6/28/29	3,837	3,828	1,200	Yes	Gravity 22.2
	8	11/21/29	3,288		Dry	No	Abandoned in anhydrite
Lempke	1	5/22/29	3,884	3,866	100	Yes	Gravity 22
	2	8/ 8/29	4,003		Dry	No	Abandoned
	3	9/15/29	3,900	3,895	Dry	No	Abandoned
	4	10/27/29	3,866	3,848	2,333	Yes	Gravity 22
	5	12/ 6/29	3,865	3,852	2,400	Yes	Gravity 22
	6	1/24/30	3,995		Dry	No	Abandoned in salt
Verdine	1	3/ 5/30	3,938	3,926	1,256	No	Gravity 22
	2	6/21/30	3,925	3,915	1,265	No	
Watkins	1	2/16/28	3,958	3,948	2,000	No	Abandoned
	2	3/ 7/28	3,970		Dry	No	Abandoned in salt
	3						Location abandoned
	4	7/14/28	3,978	3,926	20	No	Abandoned
	5	7/ 3/28	3,955	3,936	1,400	Yes	Gravity 23.3
	6	7/29/28	4,235	4,231		No	Abandoned
	7	7/28/28	3,920	3,912	1,500	Yes	Gravity 22
	8	8/ 5/28	3,909	3,897	1,200	No	Gravity 22; abandoned
	9	9/11/28	4,078	4,069	1,700	Yes	Gravity 23.8
	10	8/23/28	3,884	3,845	2,000	Yes	Gravity 22
	11	9/ 1/28	3,660			No	Abandoned

TABLE I—*Continued*

Well	*Date Completed (Month, Day, Year)*	*Total Depth (in Feet)*	*Top of Oil Sand (in Feet)*	*Initial Production (in Barrels)*	*Producing*	*Remarks Gravity References, Bé.*
12	2/ 4/28	3,960	3,949	1,000	Yes	Gravity 23.1
13	3/ 7/29	4,071			No	Abandoned in sandy shale
14	6/27/29	3,812	3,797	300	Yes	Gravity 22.2
15	7/31/29	3,871		200	Yes	Deepened to 3,964 feet
16	1/15/30	3,265		Dry	No	Abandoned in cap rock
17	4/ 7/30	2,707	2,697	1,288	Yes	Gravity 22
18	5/ 7/30	2,751	2,737	125	Yes	Gravity 22
19	7/ 2/30	3,079		Dry	No	Anhydrite
20	8/25/30	2,857	2,846	862	Yes	
21	10/19/30	3,918	3,914	71	Yes	
22	11/18/30	2,855	2,845	1,300	Yes	Gravity 23.9
I. Doiron 1	8/ 3/30	3,937	3,929	2,800	Yes	
Landry 1	10/10/30	2,612	2,592	90	Yes	
2	11/16/30	2,648	2,591	500	Yes	Gravity 20.4
State 1	11/23/30	4,083	4,070	300	Yes	Tested salt water at 3,970 feet
YOUNT-LEE OIL COMPANY						
State 6	3/12/28	3,882	3,872	150	Yes	
8	4/30/28	3,940	3,918	282	Yes	
9	6/ 1/28	3,953	3,937	2,000	No	
10	4/28/28	3,923	3,911	2,240	No	
11	6/15/28	3,946	3,920	2,200	Yes	
12	7/12/28	3,949	3,929	1,800	No	
13	7/ 8/28	3,863	3,845	2,058	No	
14	9/ 2/28	3,750			No	Abandoned in salt
16	9/ 4/28	3,939			No	Abandoned in salt
17	10/ 8/28	3,718			No	Abandoned in salt
18	10/26/28	3,800			No	Abandoned in salt
22	11/25/28	3,419			No	Abandoned in salt
30	9/22/30	3,918	3,909	1,000	Yes	
31	9/ 7/30	3,909	3,894	2,000	Yes	
32	10/29/30	3,909	3,903	600	Yes	Gravity 22.7
33	11/16/30	2,704	2,616	1,270	Yes	Gravity 18
35	11/17/30	2,696	2,615	800	Yes	Gravity 18
THE TEXAS COMPANY						
State B-1	4/25/28	3,263		Dry		Abandoned in cap rock
B-2	8/16/28	4,248				Abandoned in salt
B-3	11/13/28	3,941	3,935	600	Yes	
B-4	4/ 4/29	3,812				Abandoned in salt
B-5	9/ 5/29	4,231				Abandoned in cap rock
B-6	4/16/30	3,966				Abandoned in salt
B-7		5,130				Heaving shale
B-8						Location
THE GULF COMPANY						
Erwin 1	7/10/30	3,414				Abandoned in anhydrite

2,000,000 barrels. Of the 40 wells having some initial production of oil, more than 30 are still producing (Table I).

GEOLOGY

Surface indications are lacking at East Hackberry. The area is flat, and most of it is covered with marsh lands. Figure 1 shows Kelso Bayou, which meanders across the tops of East and West Hackberry domes.

Although Hackberry is a true salt dome, it is not of the typical Gulf Coast variety, because it is much larger than most domes in this region. It is approximately 6 miles long, and is 2 miles wide at the west end. East and West Hackberry are merely cupolas on a huge salt mass, which resembles a salt ridge more closely than a dome. Figure 1 shows the relation between East and West Hackberry. Seismographic surveys have indicated salt between the two cap-rock areas, the presence of which almost proves that these two cupolas, or knobs, are parts of the same salt mass separated by a saddle. (There is an interesting analogy between these cupolas with their oil production and the cupolas of igneous batholiths with their ore deposits.)

The shallowest cap rock at East Hackberry was encountered at 2,955 feet in Watkins No. 19. Above the cap in Watkins No. 16, Watkins No. 19, and Erwin No. 1 is a broken zone containing micro-fossils which

TABLE II

SUMMARY OF MONTHLY OIL PRODUCTION, HACKBERRY, LOUISIANA
(*Barrels only*)*

	1927	*1928*	*1929*	*1930*	*Total*
			CALCASIEU OIL COMPANY, INC.		
January	....	30,605.71	140,534.58	39,285.13	210,425.42
February	....	47,713.10	114,149.65	29,227.66	191,090.41
March	....	54,049.88	82,747.83	39,572.61	176,370.32
April	....	39,454.02	62,534.64	61,057.28	163,045.94
May	....	33,099.17	58,089.15	53,262.65	144,450.92
June	....	19,720.92	49,673.50	57,676.50	127,070.92
July	....	28,216.46	69,215.09	56,825.82	154,257.37
August	....	63,243.35	55,011.61	77,926.88	196,181.84
September	....	54,582.68	48,564.46	42,864.31	146,011.45
October	....	59,813.04	49,373.35	33,168.57	142,354.95
November	22,521.37	93,689.79	49,929.99	50,378.16	216,519.31
December	19,404.04	103,083.67	58,275.67	69,457.57	250,220.95
Total	41,925.41	627,271.63	838,099.52	610,703.14	2,117,999.80

*Foregoing production is gross, including all royalties and working interests.
Grade: Gulf Coast "A." Bé. gravity: 22-23.

are probably of lower Oligocene age. Caldwell No. 5 passed through the Oligocene at 6,998 feet. The older formations, therefore, dip away from the dome at an angle of approximately 55°. The heaving shale encountered in Caldwell No. 4, No. 5, and No. 6 dips as much as 60°. This extremely steep dip explains the narrow productive area along the south flank (Fig. 3).

None of the wells on top of the dome has penetrated the cap rock into salt. However, on the south flank twelve wells penetrated salt and were immediately abandoned; therefore, it is not known whether or not there is an overhanging ledge of salt on this dome.

STRATIGRAPHY

The East Hackberry dome lies within the Mississippi embayment area, where the upper Tertiary deposits are exceedingly thick.

At the surface are recent marsh deposits of muck, sands, and clays. Beneath the veneer of marsh deposits are sands and gravels of Beaumont age. Next occurs the thick Pliocene-Miocene series. These deposits are composed of blue sandy silts, blue and gray silty sands, clays, bluish-green shales, and some clean sands, mostly fine-grained. Under the Miocene is the Oligocene, which is composed chiefly of gray silty sands, sandy shales, and hard gray shales. The *Heterostegina* limestone seems to be absent at East Hackberry, but it has been found at Sulphur and Lockport. Below the Oligocene, heaving shale is encountered, which is generally accepted as being Jackson in age. The heaving shale has never been penetrated at East Hackberry.

Following is a geologic section of this part of southwest Louisiana.

Age		*Approximate Thickness in Feet*
Recent marsh deposits		50
Pleistocene	Beaumont	350
	Lissie	650
Pliocene		2,200
Miocene		3,000
Oligocene		500
Jackson		?

PRODUCTION

The Hackberry oil is typical heavy Gulf Coast crude. It ranges in gravity from 18° to 24° Bé., with an average of approximately 22°. One of the best wells was Watkins No. 17, which was completed on April 7, 1930, flowing 1,288 barrels of 22° Bé. gravity oil from a sand at a depth of 2,697 feet. This well is still flowing approximately 400 barrels per

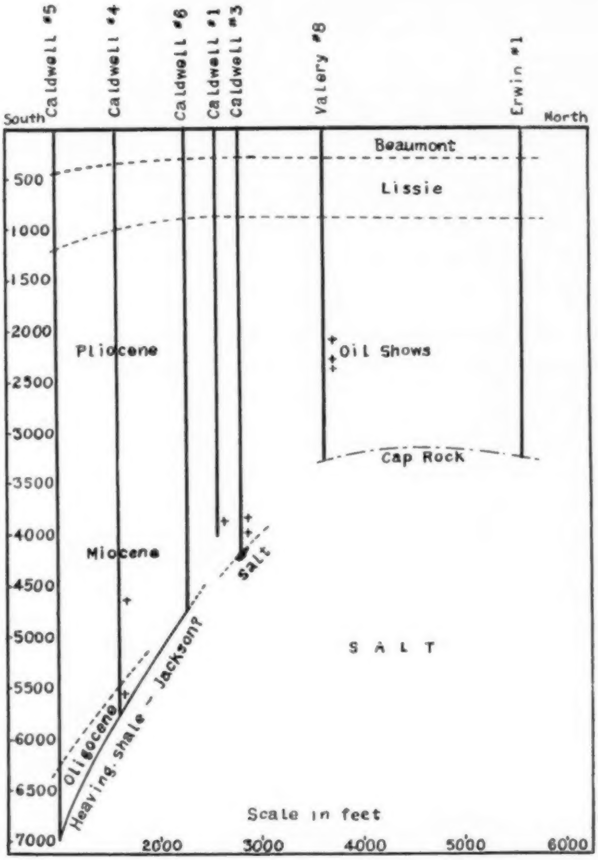

FIG. 3.—Cross section of East Hackberry. For location of wells, see Figure 2.

day. The initial production of the flank wells ranges from 25 to 2,800 barrels per day, but production generally declines rapidly as salt water encroaches.

The curve of Figure 4 illustrates the rapid decline of some of the flank wells.

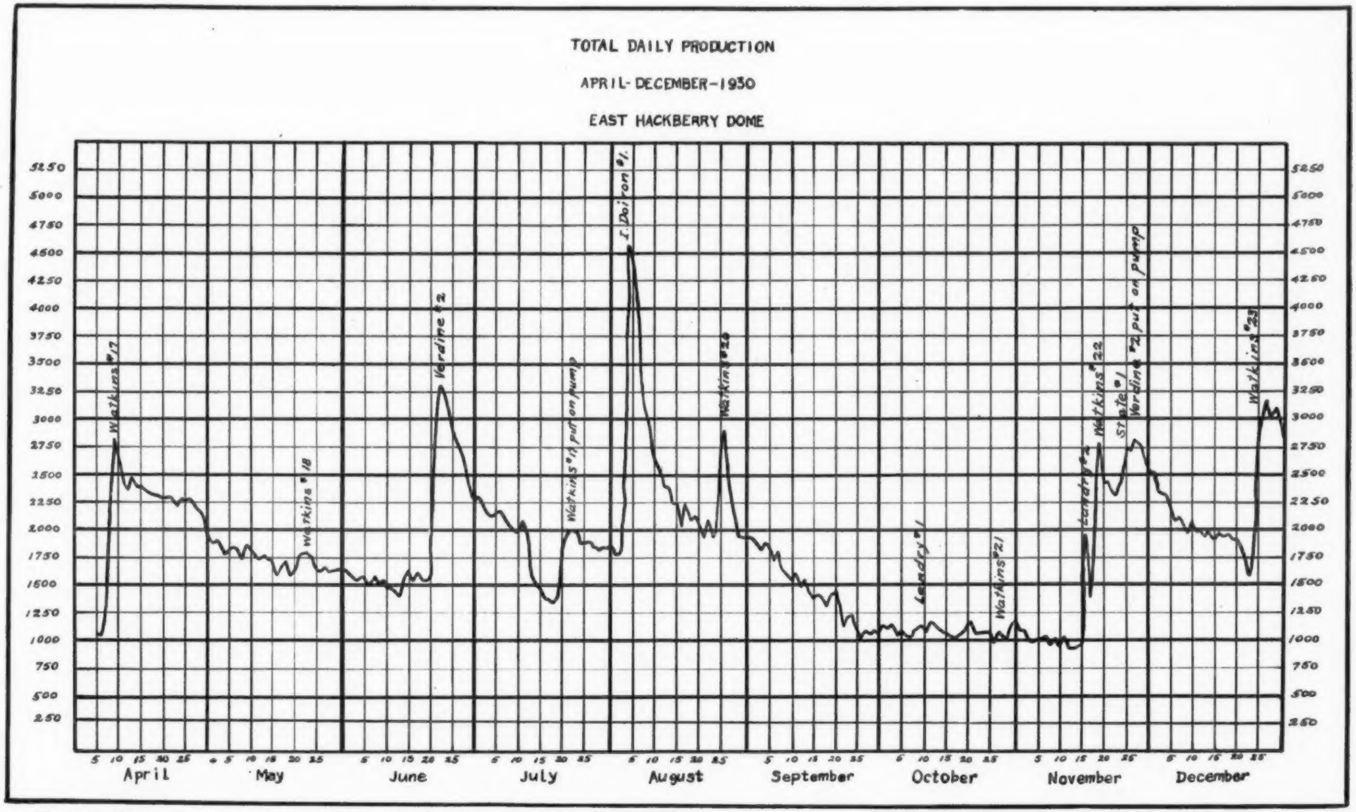

FIG. 4.—Curve showing total production, April-December, 1930. Calcasieu Oil Company, Inc. Production from 24 wells; peaks show when individual wells came in.

PALEONTOLOGY

Study of the paleontology at East Hackberry has shown the necessity of authoritative detailed descriptions of the micro-faunal assemblages found in the Tertiary deposits of the Gulf Coastal Plain. Until these are obtainable, the faunas found in these sediments will continue to be confusing to paleontologists working in this section.

Samples from the Calcasieu Oil Company's deep well, Caldwell No. 5, were sent to three paleontological laboratories. The reports from these laboratories are as follows.

Laboratory 1
- Report dated May 7, 1930, on samples from 6,608-6,615 feet—Jackson
- Report dated June 6, 1930, on samples from 6,730 to 6,872 feet—Oligocene

Laboratory 2
- Report dated September 6, 1930, on samples from 6,611 to 6,995 feet—Jackson
- Report dated October 14, 1930, on samples from 6,453 to 6,995 feet—Oligocene

Laboratory 3
- Report on same samples—highest Jackson

The foregoing confusing reports demonstrate conclusively the need for more published information and for better coöperation between Gulf Coast paleontologists.

COLLOPHANE FROM MIOCENE BROWN SHALES OF CALIFORNIA[1]

E. WAYNE GALLIHER[2]
Pacific Grove, California

ABSTRACT

Pyritized collophane oölites from the California Miocene are described. The matrix in which they occur is described briefly. Certain phases of their origin are discussed.

INTRODUCTION

Through the courtesy of Hubert G. Schenck, of Stanford University, the writer has had the opportunity to examine a large amount of material containing phosphatic oölites which, so far as he knows, have not been previously described. Not only are they of importance as horizon markers, but they are of interest because they occur in a formation which, as a whole, is not phosphatic, and because they constitute one of a group of objects in which pyrite formation has been localized.

The writer is also indebted to William F. Barbat, of the Standard Oil Company of California, for opportunities to examine material from various localities. Most of the samples used have been made available by oil companies. To R. D. Reed, of The Texas Company, Fritz E. von Estorff, of the Standard Oil Company of California, and A. F. Rogers, of Stanford University, the writer expresses his gratitude for advice and criticism.

OÖLITES

Local name.—Geologists of the southern San Joaquin Valley, California, have become familiar with the term "sporbo" (plural and singular), the local name of the oölites. This term is said to have been devised by H. M. Horton,[3] of the Superior Oil Company, by the combination of the italicized letters of *s*mooth-*p*olished-*r*ound-*b*lack (blue or brown)-

[1]Read before the Pacific Section of the Association at Los Angeles, November 6, 1930. Manuscript received, December 30, 1930.

[2]Jacques Loeb Laboratory, Hopkins Marine Station. Fellow in geology, Stanford University. Introduced by William S. W. Kew.

[3]Oral communication.

objects; it is a very adequate general description of the grains which were first determined, by A. F. Rogers,[1] as being impure collophane.

Location and stratigraphic position.—Samples examined in detail have come from depths ranging from approximately 6,200 to 6,800 feet, in the Kettleman Hills oil field, Fresno and Kings counties, California (latitude 36° N., longitude 120° W. of Greenwich), and from a depth of approximately 4,500 feet in the North Belridge oil field, which is approximately 35 miles southeast of the first locality.

All "sporbo" described in detail are from the "brown shales" of Miocene age which are more fully described by H. G. Schenck.[2]

Physical characteristics.—The size and shape of the collophane grains vary somewhat. "Sporbo" occurring in the Belridge field at a depth of 4,535 feet (Belridge Oil Company's No. 15) have both ovoid and almost spherical shapes. The average dimensions of the ovoid grains are 0.5 × 0.25 millimeter; the average width of the spherical "sporbo" is 0.3 millimeter. A comparison of Figures 2, 3, and 4 with Figure 1 shows that these "sporbo" are larger and somewhat less opaque

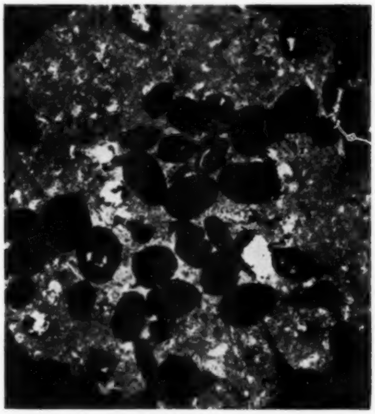

FIG. 1.—Well pyritized "sporbo" in thin section, showing sand grains in centers of several. Transmitted light. From north dome, Kettleman Hills, depth 6,133 feet. (Standard Oil Company's No. 261-11-P.) Scale: 7/8 inch = 0.5 millimeter.

[1]Oral communication.

[2]H. G. Schenck, "Miocene Brown Shales of the Kettleman Hills, California." Read before the Pacific Section of the Association at San Francisco, November 22, 1929.

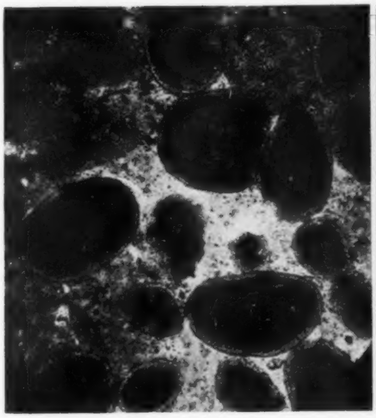

FIG. 2

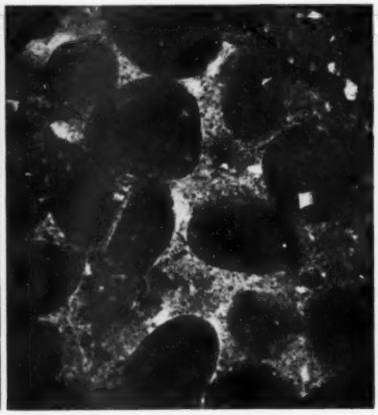

FIG. 3

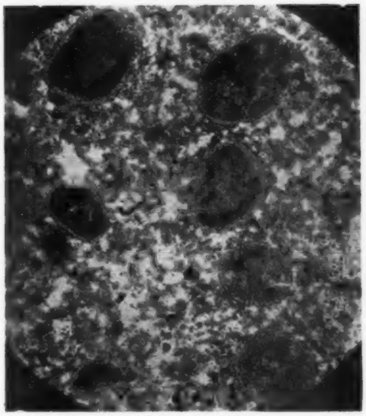

FIG. 4

FIGS. 2, 3, and 4.—"Sporbo" showing broad transparent border, two well defined transparent rings, and various degrees of pyritization. From Belridge field (Belridge Oil Company's No. 15), depth 4,535 feet. Scale: 7/8 inch = 0.5 millimeter.

in thin section than some described later. The sections show distinctly a definite border of light buff, transparent material, the width of which is apparently uniform in all grains in a specified horizon, and in this section the width is 0.008-0.01 millimeter. A few "sporbo" from this depth were marked by two of these transparent rings, the inner one being completely encircled by the outer (Fig. 3). The contact of the bordering rim with the clay matrix is very definite (Figs. 2, 3, and 4); however, the inner contact with the opaque center is somewhat gradational. This increase in opacity is due to an increase in amount of pyrite toward the center. When pyritization is almost complete, the grain has an unmistakable brass-yellow color and metallic luster in reflected light. Poor reflections are due either to the extreme minuteness of the pyrite crystals or to ferrous sulphide.

One exceptional grain from the Belridge Oil Company's No. 15 is very similar in shape to "sporbo," but is larger and, instead of being pyritized centrally, is bordered by a broken pyritized strip (Figs. 5 and 6).

The two grains in contact shown in the upper part of Figure 2 require comment. The flattened side, common to both, suggests either a molding when soft or interference due to secondary growth. The shape can not be due to sediment compaction, for none of the other single grains shows flattening.

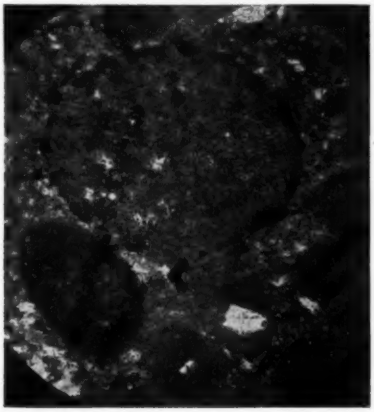

FIG. 5.—Structure similar to "sporbo" bordered by pyritized strip. Transmitted light. Same depth and locality as Figures 2, 3, and 4. Scale: 7/8 inch = 0.5 millimeter.

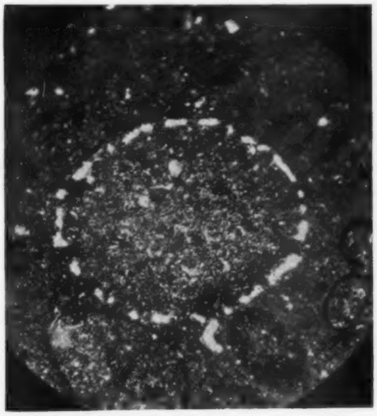

FIG. 6.—Same section as Figure 5, but photographed in reflected light. Scale: 7/8 inch = 0.5 millimeter.

From the north dome of Kettleman Hills (Standard Oil Company's No. 261-11-P), depth 6,133 feet, the width of the collophane is 0.2 millimeter in spherical grains; 0.25 × 0.15 millimeter in ovoid grains. The grains are well pyritized (Fig. 1) and the thin border (0.002 millimeter) of transparent material is visible only with very great magnification. Many of these "sporbo" contain centrally located sand grains, but lack any structure which suggests that the clastic material acted as a nucleus.

In a thin section of material from the south dome of Kettleman Hills (Ohio Oil Company's Smith No. 1), from a depth of 6,256 feet, the average measurement of grains with circular outline was 0.2 millimeter; the approximate measurement of those with oval shape was 0.3 × 0.2 millimeter (Fig. 7). The width of the transparent border ranges from 0.002 to 0.004 millimeter.

"Sporbo" occurring at depths of 6,426, 6,435, and 6,440 feet in the Pacific Western KOC No. 27, at Kettleman Hills, are similar in shape, size, and degree of pyritization to those described (Figs. 9 and 10). The average width is 0.15 millimeter, with a range from 0.10 to 0.25 millimeter; the outline is somewhat circular in thin section; and the bordering rim is remarkably uniform (ranging from 0.005 to 0.008 wide).

In general, therefore, the minimum grain width of material from the Belridge field is 0.25 millimeter and the maximum is 0.5 millimeter; and the minimum from the Kettleman Hills is 0.1 and the maximum is

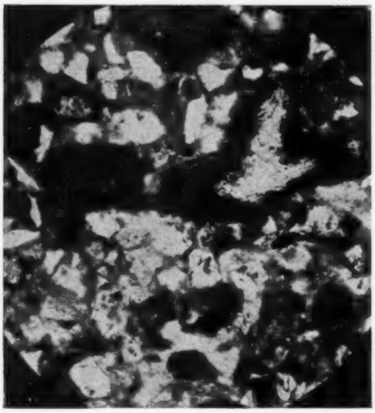

Fig. 7.—Bone fragment pyritized near outer margin, but having clear, narrow outer rim and interior. Several heavily mineralized "sporbo" are also visible in the section. Transmitted light. From south dome, Kettleman Hills (Ohio Oil Company's Smith No. 1), depth 6,256 feet. Scale: 7/8 inch = 0.5 millimeter.

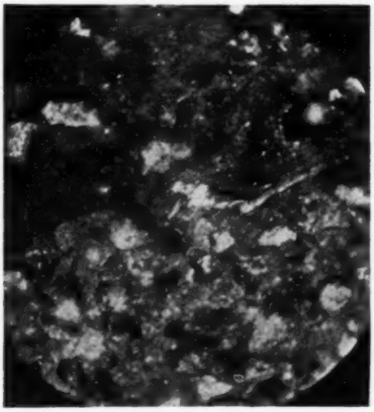

Fig. 8.—Same as Figure 7, but photographed in reflected light. Only the lower edge of the pyritized bone fragment gives a good reflection. Scale: 7/8 inch = 0.5 millimeter.

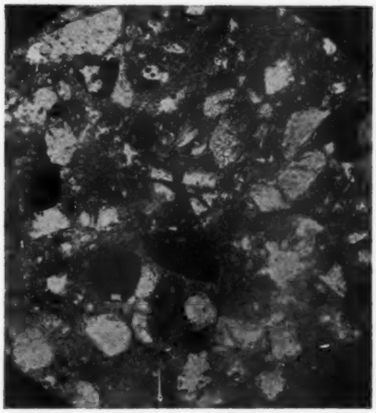

FIG. 9.—Microphotograph of section of shale from 6,440 feet depth, south dome, Kettleman Hills, in ordinary light, showing elliptical grain oriented perpendicular to the bedding which extends from lower left to upper right corner. (Ohio Oil Company's Smith No. 1.) Scale: 7/8 inch = 0.5 millimeter.

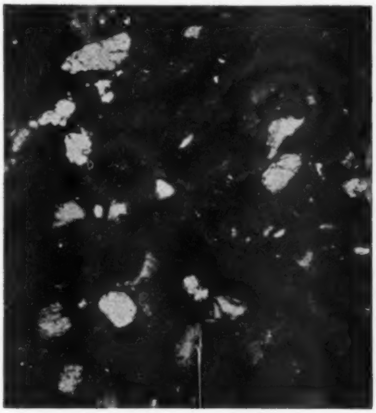

FIG. 10.—Same as Figure 9, but photographed between crossed nicols. Scale: 7/8 inch = 0.5 millimeter.

0.25 millimeter. Shapes of grains range from ovoid to spherical. Some "sporbo" are more pyritized than others, those from the Belridge field being least pyritized.

As has been previously stated, the opacity of "sporbo" varies with degree of pyritization. In transmitted light the border is generally light buff, but the color varies from grain to grain. Between crossed nicols this material remains dark and is, judged from the general form, amorphous. Indices of refraction range from 1.54 to 1.61, the lower index being found most generally in grains not greatly pyritized. The index of the material used in the chemical analysis was determined as 1.605 ± 0.002. The appearance in reflected light is entirely dependent on the degree of pyritization.

The fact that a gravity separation in bromoform (specific gravity, 2.7) yields grains of collophane in both "heavies" and "lights" is indicative of different specific gravity, probably due to difference of pyrite content. Hardness likewise varies with pyritization; however, most grains are easily scratched with a needle point.

Chemical composition.—Eighty-five milligrams of grains, carefully washed and picked to free from attached sediment, were analyzed, with the following results.

	Per Cent
Insoluble	9.8
Fe_2O_3	2.1
CaO	41.2
MgO	Trace
P_2O_5	30.7
CO_2	3.7
S	1.4
H_2O	11.1
	100.0

Examination of the insoluble part showed that it was quartz, feldspar, and clay.

The material analyzed was from the Pacific Western KOC No. 27, from a depth of 6,426 feet. The analysis varies somewhat from that of pure collophane,[1] but is similar to analyses of Florida phosphorites.[2]

MATRIX

As the figures indicate, the lithology of the sediment in which "sporbo" occurs is variable. Little may be said of the clay phase, be-

[1] Austin F. Rogers, "Collophane, a Much Neglected Mineral," *Amer. Jour. Sci.*, Vol. 3 (1922), p. 273.

[2] F. W. Clarke, "The Data of Geochemistry," *U.S. Geol. Survey Bull.* 770 (1924), p. 533.

cause the extreme smallness of the particles makes microscopic determination of the species unreliable. The uniform light buff color in thin section is noteworthy. In cores from deep wells the shale has a dark bluish gray color. Surface samples are, however, light brown, a staining derived from the oxidized iron of the pyrite (hence the name "brown shales").

In the Belridge field at 4,535 feet, "sporbo" occur in a matrix of approximately 70 per cent[1] clay, 5 per cent angular quartz and feldspar (both orthoclase and plagioclase), 1 per cent or less of black, elongate, pyritized fragments, and the remainder "sporbo," the quantity of which may vary considerably, the maximum being 20 per cent. Examination in thin section shows that the sand grains are well sorted and that the average diameter is 0.008 millimeter (limits 0.006 and 0.018 millimeter).

The shale from 6,133 feet on the north dome, Kettleman Hills (Standard Oil Company's No. 261-11-P), contains not more than 10 per cent angular clastic grains with dimensions of 0.1-0.15 millimeter. The remainder consists of clay and "sporbo," the latter probably not more than 30 per cent in any inch-square area, but being characterized by sporadic or "blotched" occurrence.

From depths of 6,256, 6,435, and 6,440 feet in the south dome, Kettleman Hills (Ohio Oil Company's Smith No. 1), the sediment contains 50 per cent angular quartz and feldspar (80 per cent of which ranges from 0.1 to 0.2 millimeter in width), 40 per cent clay, 5 per cent material showing organic structures (bones, fish scales, pyritized diatoms), and 5 per cent "sporbo." The organic material, especially bone fragments, is also well pyritized (Figs. 7 and 8).

In general the long axis of the ovoid collophane grains lies parallel with the bedding. There are places, however, where the long axis of the grain lies almost at right angles to the trace of the bedding (Figs. 9 and 10).

In the sample from the Pacific Western well mentioned on page 261, "sporbo" occur in lenses parallel with the bedding and in small oval pockets. Outside of these areas of concentration the shale is almost barren of "sporbo." Lenses are not continuous for more than 4 inches and range from ¼ to ¾ inch in thickness. The oval pockets are approximately ¼ inch wide and ½ inch long. Seven such areas were observed on a core surface 3½ inches wide and 4 inches long. In concentrations such as these, "sporbo" may constitute as much as 30 per cent

[1]Percentage by volume, estimated.

of the volume of the rock, the remainder being angular sand grains ranging from 0.1 to 0.05 millimeter in diameter, and some clay. In the same well, but 9 feet lower, the shale consists of 60 per cent well sorted sand (0.1-0.05 millimeter in diameter), 30 per cent clay, trace of chlorite, and 10 per cent "sporbo."

In brief, therefore, the matrix is mainly clay, but if coarser clastic material is present it may be classified as very fine sand.[1] The sand is almost entirely quartz and feldspar. No tuffaceous material has been observed. Although the collophane grains do not lie parallel with the bedding, in general, and although lenticular areas of concentration are syngenetic features, there are beds which, when studied in detail, show definite orientation of grains.

OTHER OCCURRENCES

To make the description as complete as possible at present, several other occurrences of oölites in the California Miocene are worthy of record. R. D. Reed[2] has mentioned the occurrence of similar objects in what is commonly known as Temblor shale in the Miocene section near Santa Barbara, California. He has also sent the writer material from the siliceous shales of Miocene age in Reliz Canyon, Monterey County, California. The oölites examined occur 600-700 feet above the Vaqueros sandstone (lower Miocene). In shape and size they are similar to the "sporbo" of Kettleman Hills, but are unpyritized.

The Monterey shale exposed in Carmel Valley approximately 15 miles from Carmel, California, contains a bed of these phosphatic concretions. This bed, approximately 8 inches thick and persistent for at least 65 feet, is a solid mass of ovoid grains less than a millimeter in maximum diameter, which are loosely cemented together with limonite. These objects, as well as those described in the preceding paragraph, can not be strictly termed "sporbo"; this name should be reserved for the pyritized grains.

GENERAL DISCUSSION

The literature on phosphatic sediments and structures peculiar to them can not be mentioned in detail in this paper. It may only be stated that the oölites described in the preceding pages are probably in the same general category as the phosphatic concretions described in the Challenger

[1]U. S. Bureau of Soils standards.

[2]R. D. Reed, personal communication, May 17, 1930.

reports.[1] Various other origins which have been considered, as fish and holothurian excrement, megalospheres of *Foraminifera*, eggs of the brine shrimp *Artemia salina*, ostracod excrement, and termite pellets,[2] have been discarded for many reasons.

The mechanism of the formation of phosphatic nodules is only partly understood, but the general idea of the dynamics of the process as given by Murray and Renard is considered the most plausible. In brief, this process requires the decomposition of organic remains and possibly the presence of ammoniacal salts and albuminoid matter.[3] This leads to the question of concretion formation, a subject outside the scope of this paper.

The pyritization of the oölites remains to be considered. The evidence available fails to show at exactly what stage or stages in the history of the rock the process of disulphide formation occurred. This study has suggested pyritization at a time after the oölites assumed their present form, that is, after they became somewhat hardened. However that may be, certain possible steps in the formation of the iron disulphide may be mentioned.

The blue marine muds are characterized by hydrotroilite, $FeS_x(H_2O)_y$. Not only black and blue marine muds, but saline lakes, sloughs, marshes, and fresh-water lakes may have black bottom-sediments because of ferrous sulphide, if the water is capable of furnishing the sulphate radical for the metabolism of the anaerobic sulphur bacteria. Details can not be considered in this paper, but it may be stated that the reduction of sulphur of the sulphate ion to H_2S by the sulphate reducers, and the oxidation again to sulphate is a cycle in which the black mud is an important factor, chiefly as a reserve for sulphide. Becking[4] has outlined clearly the general conditions existing in such an environ-

[1]John Murray and A. F. Renard, "Phosphatic Concretions," *Rept. Challenger Expedition, Deep Sea Deposits*, Chap. VI, Sec. IV (1891), pp. 391-400.

[2]S. F. Light, "Fossil Termite Pellets from the Seminole Pleistocene," *Univ. California Pub., Bull. Dept. Geol.*, Vol. 19 (1930), pp. 75-80.

[3]For a summary of discussions of the processes involved see G. R. Mansfield, "Geography, Geology, and Mineral Resources of a Part of Southeastern Idaho. With Descriptions of Carboniferous and Triassic Fossils," by G. H. Girty, *U. S. Geol. Survey Prof. Paper 152* (1927), pp. 361-67; A. Barille, "Rôle, dans la nature, de la dissociation des carbonophates," *Compte Rendu, Tome 148* (1909), pp. 344-46. An interesting formation of phosphatic concretions (collophane) under non-marine conditions is noted by P. T. de Chardin, "Sur une formation de carbono-phosphate de chaux d'âge paleolithique," *Compte Rendu, Tome 157* (1913), pp. 1077-79.

[4]L. G. M. Baas-Becking, "Studies on the Sulphur Bacteria," *Annals of Botany*, Vol. 39, No. 155 (1925), pp. 613-50. Contains an excellent bibliography.

ment. The sulphuretum is dominantly alkaline; ample hydrogen sulphide is provided; the H_2S will react with any soluble ferrous salt present in the water, precipitating hydrotroilite which, in turn, serves as a source of H_2S and sulphur for later use by the sulphur oxidizers. Under certain conditions excess sulphur is provided. The hydrotroilite content of a black mud is, of course, variable. Vardabasso[1] reports 6.8 per cent of sulphur (mostly as ferrous sulphide) from Black Sea sediments; whereas black sand and mud from Elkhorn Slough, Monterey County, California, contains 3-5 per cent FeS.

The step to the formation of the disulphide of iron is apparently simple. Alkalinity of the solution determines the crystallographic form. Allen and Crenshaw,[2] after examining springs in Arkansas where pyrite is now forming, concluded that the alkalinity of the water "irrespective of the temperature is sufficient to condition the formation of pyrite"[3] (as contrasted with marcasite). Furthermore, the examination of black sediment from wells in St. Louis, Missouri, and Columbus, Kansas, showed that it consisted of ferrous sulphide, free sulphur, and a substance resembling pyrite. Their explanation of disulphide formation is: precipitation of ferrous sulphide and sulphur from reaction of a soluble polysulphide with a ferrous salt, the FeS and S uniting at 100° C. to form amorphous disulphide which, later, crystallizes to pyrite. They state,[4] "In the waters of the springs and wells which have just been cited, it is plain that the processes go on very slowly at ordinary temperature."

In this reaction there is a logical explanation for the formation of pyrite. An example of active pyritization has been observed by the writer. A small area on the umbo of a *Saxodomus* shell buried approximately 1 foot in the black sand of Elkhorn Slough was covered with a thin layer of pyrite. All available evidence indicates that this is an example of pyritization, *in situ*, in the sulphuretum.

SUMMARY

1. An impure, pyritized, oölitic collophane occurs in the Miocene "brown shales" of the southern San Joaquin Valley, California. These

[1] Silvio Vardabasso, "Origin and Composition of the Sediments of the Black Sea" (title translated), *Ann. scuola ing. Padova*, Vol. 4 (1929), pp. 309-14.

[2] E. T. Allen and J. L. Crenshaw, "Effect of Temperature and Acidity in the Formation of Marcasite (FeS_2) and Wurtzite (ZnS); a Contribution to the Genesis of Unstable Forms," *Amer. Jour. Sci.*, Vol. 38 (1914), pp. 393-431.

[3] *Op. cit.*, p. 428.

[4] *Op. cit.*

oölites have the local name of "sporbo." Similar objects have been observed in sediments of the same general age in many parts of California.

2. The size limits of the oölites fall within two fairly definite dimensions: in one group the dimensions range from 0.1-0.25 millimeter; in the other the dimensions range from 0.25 to 0.5 millimeter. In any particular occurrence the grains seemingly never exceed the dimensions given for the group in which they belong.

3. The chemical composition and physical properties of "sporbo" depend on the degree of pyritization.

4. Grains are embedded in a matrix which is dominantly clay, but if coarser material is present it is a well sorted, angular, very fine sand.

5. "Sporbo" are syngenetic, but when studied in detail many grains are seen to have an arrangement independent of the bedding of the shale and suggesting, in some examples, secondary growth.

6. The oölites are considered as being in the same general category as the phosphatic nodules described in the Challenger report.

7. The mechanism considered in this paper explains pyrite formation; an example of active pyritization has also been cited.

COMPACTION OF SEDIMENTS[1]

PARKER D. TRASK[2]
Princeton, New Jersey

ABSTRACT

The initial water content of sediments varies with the fineness of the constituent particles. A tentative estimate indicates that it is approximately 45 per cent in well sorted fine-grained sands, 60 per cent in silts, 80 per cent in clays, and more than 90 per cent in colloids. In general, deposits that accumulate over submerged ridges are coarser than those that form in basins. Consequently, sediments deposited on submarine topographic "highs" should compact less than those that accumulate in "lows."

During the past few years the subject of compaction of sediments has been of interest to petroleum geologists. Work on the American Petroleum Institute's research project, "The Origin and Environment of Source Sediments," has revealed several facts relating to the problem. The most important of these is that the initial water content of sediments varies with the texture of the deposits.

In the Channel Islands region of California the water content of the highest layers of the bottom deposits varies with the texture of the sediments. The more fine-grained the sediment, the greater is the initial water content.[3] In these deposits it ranges from 29.5 per cent in a fine sand to 66 per cent in a fine silt.[4]

Compaction of sediments under centrifugal acceleration shows the same phenomenon. In making mechanical analyses of fine sediments with a centrifuge, one prepares a uniform suspension of all the con-

[1]This paper contains results of an investigation on "The Origin and Environment of Source Sediments," listed as Project 4 of the American Petroleum Institute research program. Financial assistance in this work has been received from a research fund of the American Petroleum Institute donated by John D. Rockefeller. This fund is administered by the Institute with the coöperation of the Central Petroleum Committee of the National Research Council. Manuscript received, January 26, 1931.

[2]Frick Chemical Laboratory.

[3]For detailed discussion of this relationship see W. W. Rubey, "Lithologic Studies of Fine-Grained Upper Cretaceous Sedimentary Rocks of the Black Hills Region," *U. S. Geol. Survey Prof. Paper 165-A* (Washington, D. C., 1930), pp. 31-38.

[4]Parker D. Trask, "Results of Distillation and Other Studies of the Organic Nature of Some Modern Sediments," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 11, No. 11 (November, 1927), p. 1227.

stituents, places it in a tube, and records the increase in weight of particles that settle out during successive intervals of centrifuging. The sands are thrown down first, the silts next, then the clays, and finally the colloids. During subsequent intervals of centrifuging, the particles that have previously come down are compacted. Many observations of this compaction show that colloids are compacted more than clays, clays more than silts, and silts more than sands. Sands are compacted very little.

In making mechanical analyses one deals with the complete range in size of particles in the sediment. During the time it takes all the constituents of any particular diameter to fall from the suspension, some of the particles of smaller diameter, because of their position near the bottom of the tube, also come down. Thus, although the average size of the constituents settling out decreases with time of centrifuging, the particles that come down during any interval of centrifuging are far from uniform in size. Furthermore, deposits differ as to proportions of fine and coarse constituents. Also, a certain amount of compacting occurs in that part of the sediment that is deposited during one centrifuge interval. Consequently, it is not apparent from casual inspection what the quantitative relations of compaction to particle size are, but it is very evident that the finer the sediment the more it will be compacted. Inasmuch as compaction is effected by expulsion of water, fine sediments have a greater initial water content than coarse.

In order to procure quantitative data on the relation of particle size to initial water content, the writer separated a fine sediment into a series of size groups. This was accomplished by decanting the particles larger than 64 microns, placing the resulting silt-clay suspension in a tube, centrifuging it until all constituents larger than 16 microns had come down, pouring off the supernatant suspension, adding more water, stirring up the sediment, centrifuging again until all particles larger than 16 microns had settled out, pouring off the supernatant suspension, and repeating the process until nearly all particles finer than 16 microns had been removed from the sediment. In this manner a suspension of constituents ranging in size from 16 to 64 microns was obtained. The supernatant suspension, containing no particles larger than 16 microns, was treated in the same manner, until its constituents had been separated into the following size groups: 4-16 microns, 1-4 microns, and less than 1 micron. From some sandy samples, size groups of 64-125, 125-250, and 250-500 microns were obtained by sieving.

Suspensions of these various size groups were placed in 100-cubic centimeter conical Goetz tubes supplied with a graduated collection

chamber, and allowed to settle for a time sufficient for all constituents of the particular size group to fall. The settling was under the influence of gravity, and the column of sediment ranged from 2 to 4 centimeters in height. Compaction caused by weight of overlying sediment was, therefore, very slight, and the data should give quantitative measures of the relation of initial water content to texture for this sample.

Table I shows the results of this experiment. The data are all based on duplicate tests. The first column gives the size groups; the second

TABLE I

RELATION OF INITIAL WATER CONTENT OF SEDIMENTS TO TEXTURE

Size-Group (Microns)	*Weight-Volume Ratio*	*Estimated Water Content (Per Cent)*
250–500	1.43	45.0
125–250	1.42	45.4
64–125	1.38	46.9
16–64	1.26	51.6
4–16	.88	66.2
1–4	.37	85.8
0–1	.046	98.2

gives the ratio of weight in grams to volume in cubic centimeters; and the third gives the percentage of water in the sediment as estimated according to the formula $W = (1 - R/D) \times 100$, where W is the per cent of water, R, the weight-volume ratio, and D, the specific gravity of the constituents, which is assumed to be 2.6.

The table shows conclusively that the initial water content of sediments varies with the texture. The sands have an almost constant weight-volume ratio of 1.4, which corresponds with an estimated water content of 45 per cent. The coarse silts (16-64 microns) have a weight-volume ratio of 1.26, which is only slightly less than that of the sands; but in the finer groups, the weight-volume ratio decreases rapidly as the particles become smaller. In the fine silts (4-16 microns) it is 0.88, which is equivalent to a water content of 66 per cent, and in the clays (1-4 microns) it is 0.37, which corresponds with a water content of 86 per cent.

The colloidal part, consisting of particles smaller than one micron, flocculated. Its weight-volume ratio was 0.046, and its estimated water content was 98 per cent. These figures may not apply to non-flocculated sediments; but certain semi-quantitative data obtained from compaction experiments with a centrifuge indicate that the weight-

volume ratio for colloids is probably less than 0.25, which means that the water content is more than 90 per cent. Extrapolation of the curves in Figure 1 showing the relation of water content to texture indicates that the water in colloids must be very high and that the data obtained from the flocculated sample may be approximately correct.

Figure 1 is an attempt to show the relation of water content to texture. The weight-volume ratio and the initial water content are plotted against the geometric mean of the extreme diameters for each

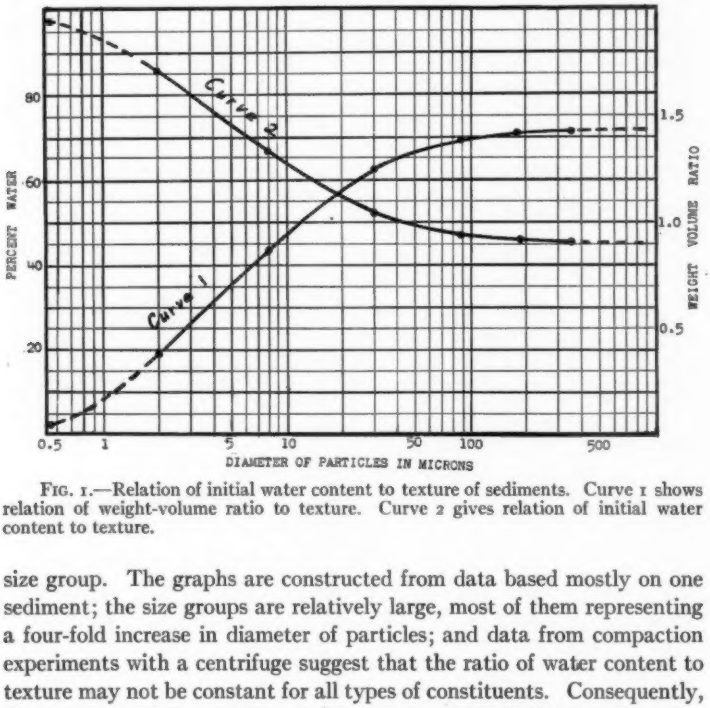

FIG. 1.—Relation of initial water content to texture of sediments. Curve 1 shows relation of weight-volume ratio to texture. Curve 2 gives relation of initial water content to texture.

size group. The graphs are constructed from data based mostly on one sediment; the size groups are relatively large, most of them representing a four-fold increase in diameter of particles; and data from compaction experiments with a centrifuge suggest that the ratio of water content to texture may not be constant for all types of constituents. Consequently, the curves must be considered as only tentatively indicating the probable order of magnitude.

The relation of the compaction of sediments to buried ridges is also of interest. Detailed studies of several environments of deposition of recent sediments have shown that the texture of deposits is more or less strongly influenced by the configuration of the sea bottom. The

active principle in this, of course, is the influence of submarine topography on currents. In general the sediments that accumulate on topographic "highs" are coarser than those that are deposited in "lows."[1]

Inasmuch as the initial water content of deposits varies with the texture, the water content of the sediments on the ridges should be less than that of the deposits in the depressions. Thus, though the sediments in the basins originally may have had a greater volume than those on the divides, the sediments in the "lows," after the deposits have been compacted by the weight of younger rocks, may occupy less space than those on the "highs." The amount of this differential compacting, among other factors, will depend on the difference between the texture of the deposits on the ridges and that of the sediments in the basins.

For example, in the Channel Islands of California a deposit in the bottom of a depression, in 700 fathoms of water, has a median diameter of 5 microns. This means that one-half the weight of the sediment is composed of particles larger in diameter than 5 microns, and one-half is composed of constituents smaller than 5 microns. A deposit on the slope out of the basin in 375 fathoms of water has a median of 25 microns. Although this is five times larger than the median of the sample from the bottom of the depression, both deposits, on consolidation, would make shales that would probably be difficult to differentiate macroscopically. According to Figure 1, a median diameter of 5 microns indicates an initial water content of 73 per cent, and a median of 25 microns indicates a water content of 53 per cent. If the water content is reduced subsequently, by compaction, to 10 per cent, the former would lose 70 per cent by volume and the latter 48 per cent.

Thus, although contemporaneous sediments in various parts of a formation consist of shale, it is not logical to conclude that if they are subjected to the same load they will compact equally. Of course, in some formations they may, but if they differ in texture, the differences in initial water content would presuppose a differential compaction.

The question of compaction is more complex than is indicated in the foregoing brief treatment. Varying amounts of clay and colloid constituents in a sediment will alter the initial water content as given in Figure 1; the data relate to fresh sediments, and do not take into account the decrease of water content downward in the deposit because of the weight of overlying particles; sediments do not accumulate at a

[1]Parker D. Trask, "Sedimentation of Channel Islands Region, California," *Econ. Geol.*, Vol. 26 (1931), pp. 24-43. Also unpublished data that will appear in the writer's final report for this work.

uniform rate upon all parts of an area of deposition; the influence of texture on the compaction of sediments is not well known; and the data given in this paper are preliminary in nature, subject to correction. However, though these phases of the problem may modify the figures given in the foregoing example, the general effect remains unchanged. Deposits that accumulate in topographic "lows" in general are finer than those that form on "highs." Consequently, the sediments deposited in depressions have opportunity to compact more than those that accumulate on ridges and divides.

GEOLOGICAL NOTES

CHESTNUT DOME, NATCHITOCHES PARISH, LOUISIANA

C. L. Moody, of The Ohio Oil Company, at Shreveport, Louisiana, has kindly permitted publication of the following facts, quoted from a letter with reference to the Chestnut salt dome, where drilling revealed an unexpectedly large central basin.

The dome is located in Choctaw Creek, a branch of Saline Bayou, and centers in Sec. 23, T. 13 N., R. 6 E., Natchitoches Parish, Louisiana. It was discovered in 1926 by areal geologic methods and our company drilled three unsuccessful tests thereon during the following year.

The surface manifestation of the dome is almost entirely confined to the recognition of a basal Claiborne (Cane River-Mount Selman) inlier in a normal Sparta sand area. Certain large chalcedony fragments, evidently replacements of some of the Tallahatta-like beds of the basal Claiborne, are strewn over the surface. This type of material I know only from two other domes, Prothro and the Winnfield quarry, although we encountered similar rock underground in drilling on the Sikes and Coochie Brake domes. Few topographically distinct features of doming occur. The dome lies in a normally dissected region, a small creek bottom occupying not the center of the uplift, but the south flank. The "apex" of the structure is a sand hill of very ordinary appearance which I took to be a Wilcox inlier, as in truth part of it really is, but later developments show that a part of it must be of early Pleistocene age.

Our first well was The Ohio Oil Company's L. & A. Oil Company No. 1 in the SW. ¼, SE. ¼ of Sec. 23, T. 13 N., R. 6 E. The top of the Cretaceous was reached in this well at 1,305 feet, indicating an uplift of about 900 feet. A more or less shortened but normal section of Upper Cretaceous was penetrated; cap-rock material was reached at 2,720 feet, and solid salt was cored at 2,885 feet, total depth 2,905 feet.

The second test was chosen in the supposed Wilcox inlier in the NE. ¼, SW. ¼ of Sec. 23, T. 13 N., R. 6 E., only about 1,900 feet northwest of the first well; it is The Ohio Oil Company's Thomas No. 1. This test met with "quick sand" which could be washed down with the pump for the first 700 feet, below which, at intervals, gummy clay drilling was encountered. I very much regret that no coring was done above 1,100 feet. The first core taken at about this depth consisted of loose sand containing a novaculite pebble or two which must be of Citronelle age at the earliest.

Some lignite fragments were later found in the cuttings. Other cores were of unbedded coarse sand.

The first determinable core was cut at 1,640 feet. To our surprise this core revealed brown shale and glauconitic marl containing the *Ostrea lisbonensis*

fauna which was used in mapping the surface structure. Core after core of the Cane River was now cut. Many of these were standing edgewise, others were completely mashed, and all were traversed by coarsely crystalline calcite veins. The last of this material was cored at 1,950 feet. You will notice that beds of definite Lower Claiborne age were present in this well at the same depth that the lower part of the Nacatoch sand was struck in the near-by test. Hard sands which have not been identified lie above the cap-rock material and beneath the last determined Claiborne. The top of the salt was reached at 2,450 feet in this well, or 435 feet shallower than in the first test.

The third well, The Ohio Oil Company's L. & A. Oil Company No. 2, was located in the NW. Cor. of the NE. 1/4 of Sec. 26 about 1/4 mile south of the first well; it was not drilled into salt, but reached the first red shale about 600 feet deeper than the same point was found in L. & A. No. 1.

Projecting the dip of the surface Claiborne beds and allowing a reasonable flattening on the summit of the dome, I think that it is safe to say that this structure experienced a central collapse in which the net slumping amounts to 2,500 feet.

F. H. LAHEE

DALLAS, TEXAS
February 4, 1931

DISCUSSION

CLAY CREEK DOME, WASHINGTON COUNTY, TEXAS

The paper by F. E. Heath, J. A. Waters, and W. B. Ferguson, on "Clay Creek Salt Dome, Washington County, Texas,"[1] merits the attention of all students of salt-dome origin, for nowhere else in North America, as far as we know, have so many definite stratigraphic horizons been established in the drilling of a similar structure; therefore, nowhere else have we as clear a picture of the subsurface geology associated with the dome. Since this paper was written, several additional wells have been drilled along the line of section *A'A* (see p. 50), with the result that new data have been secured which notably modify some of the hypotheses offered in the original article. We are reproducing this section, in Figure 1, with the new data shown in correct relative position. Our object now is to summarize the important facts and conclusions based on this revised section, but without taking the time or space to compare all of them with the original text. We believe that repetition of some of the statements made by the authors is justified in view of the theoretical importance of the structure.

1. The centrally located hole, No. 8a, encountered the top of the Yegua formation at 1,180 feet; passed through 462 feet of Claiborne in which the Yegua, Cook Mountain, Weches, Queen City, and Reklaw were all present, each with less than normal thickness; passed through only 336 feet of Wilcox; encountered limestone cap rock at 1,978 feet, anhydrite from 2,115 to 3,165 feet, and salt at 3,165 feet. This thickness of cap rock, totalling 1,187 feet, was quite out of harmony with the hypothesis proposed by Heath, Waters, and Ferguson, that cap rock might be absent in the central area (see p. 57).

2. As brought out by the authors, the central part of the dome has been depressed, so that the structure is now a closed dome with a cup-like basin at its top. Oil is found in "highs" on the lips of this basin. Within the basin the Oakville (Miocene) and Catahoula (Oligocene) formations are abnormally thick, but all the older divisions (Jackson, Yegua, Cook Mountain, Weches, Queen City, Reklaw, and Wilcox) are abnormally thin. The Sparta and Carrizo sands, present on the flanks of the dome, are absent in well 8a. These facts are indicated in Table I (figures in feet).

3. From these relations there can be little question that, beginning at least as early as Wilcox time and continuing through part or all of Jackson time, uplift of the salt plug, very probably accompanied by its anhydrite cap, was essentially simultaneous with sedimentation. The process was probably not perfectly uniform, but throughout all this long duration of time, the gradual settling of the coastal region and the associated building of the sedimentary

[1] *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 15, No. 1 (January, 1931), pp. 43-60.

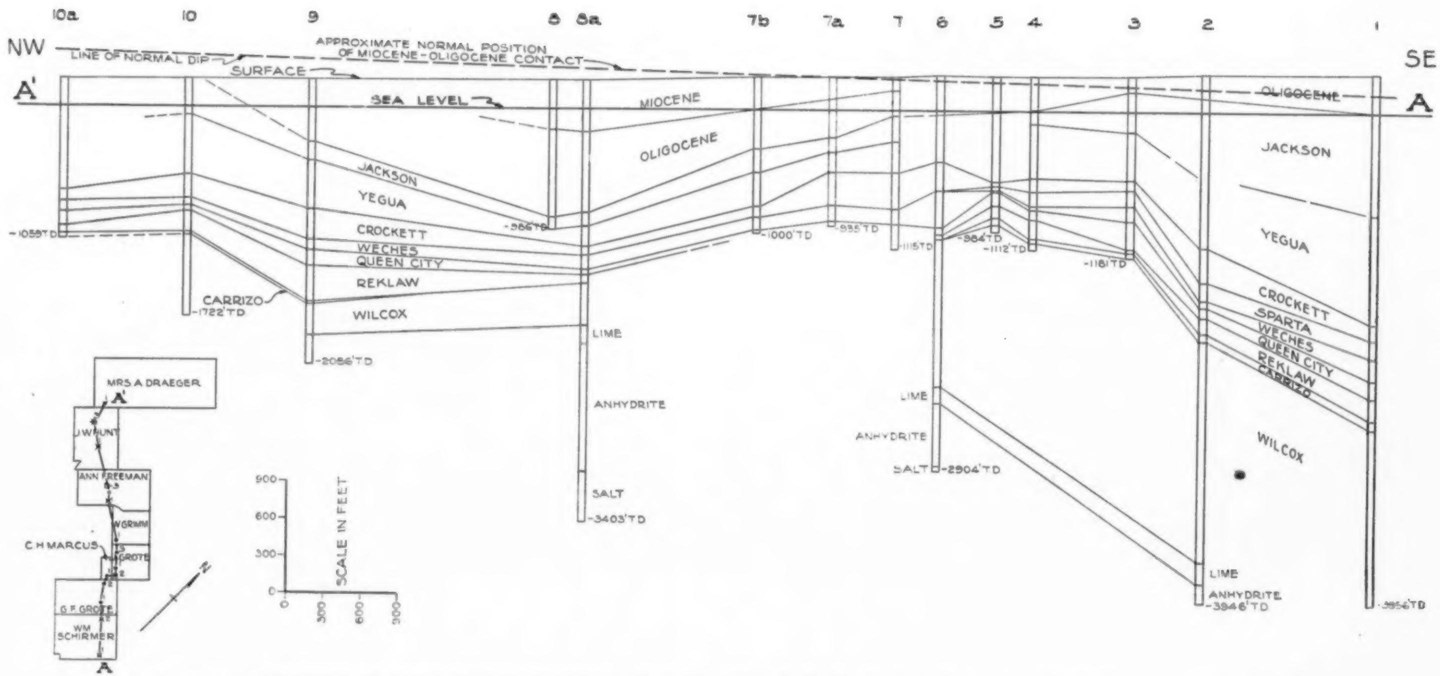

FIG. 1—Northwest-southeast log section through Clay Creek salt dome. (After F. E. Heath .J. A. Waters, and W. B. Ferguson, with revisions.)

TABLE I

Formations	Thickness					
	A *Normal*	*B* *In Hole 8a*	*C* *Excess of B Over Normal*	*D* *In Hole 2*	*E* *In Hole 1*	*F* *Difference Between B and D or E*
Oakville (Miocene)	100	430	330			
Catahoula (Oligocene)	250	640	390		315+	
Jackson	800	115			830	715
Yegua	800	170		560	870	700
Cook Mountain (Sparta at base)	450	70		435	275	205
Mount Selman Weches Queen City Reklaw (Carrizo)	800	225		330	575	350
Wilcox	2,500	335		1,770	1,400+	1,435
Totals, Jackson to Wilcox		915				3,405

prism outside the dome seem to have been nearly balanced, in rate, by the rise of the plug.

4. Previous to middle or late Wilcox time the history of this dome is uncertain. The plug might have come up simultaneously with deposition of Midway and older formations, or it might have been intruded through some or all of them. Whatever strata it might have bowed up above it were eroded before the time when the Wilcox, now present, was deposited. However, (1) the absence of beds older than Wilcox on the plug as deep as drilling has penetrated, and (2) the fact that the cap rock is thickest in the central area[1] (which must have once been relatively higher than it is now), militate against a theory of removal of roofing strata by early Wilcox or pre-Wilcox erosion, but rather suggest a period of vigorous upward injection of the plug through pre-Wilcox strata.

5. As an approximate measure of the amount of uplift of the plug from the lowest Wilcox penetrated in the drilling to the end of Jackson time, we may use the difference between the combined thicknesses of these formations

[1]The cap has been penetrated in two other wells, Mrs. Grote 2 (well No. 6 in Figure 1), where it is 634 feet thick, and Janner 4, 4,800 feet southwest of Freeman 1 (well 8a in Figure 1), where it is 600 feet thick.

(a) in well 8a and (b) on the outer flanks of the dome (wells 1 and 2). This difference is about 3,405 feet (Table I). This figure must be reduced somewhat because the beds dip at an average angle of fully 35° in the vicinity of wells 1 and 2. If allowance is made for this dip, the figure for the minimum amount of uplift between Wilcox and Jackson time, inclusive, becomes 2,600 feet.

6. Assuming that the top of the Jackson formation in wells 8a and 3 was once approximately horizontal, we have a measure of the minimum amount of post-Jackson settling of the central region, namely, about 1,000 feet, or, allowing for present normal regional dip, fully 1,100 feet.

7. The abnormally great thickness of Catahoula and Oakville in the central basin (Table I) suggests settling simultaneously with the deposition of these strata.

8. The gradual dip of the several formations from the lip inward toward the center of the basin (Fig. 1) suggests that the settling was not localized as if due to faulting, but was gradual and more or less uniformly increasing to the middle of the basin.

9. Salt domes are generally conceived of as sharp uplifts, with all or nearly all the associated strata, except the youngest, raised far above their normal position on regional dip. In the Clay Creek dome, if we use the average figures for normal thickness (Table I) and regional dip, we find that the maximum uplift of the base of the Oligocene above its estimated normal position (at well 3) is about 200 feet, whereas, in the central area it has been depressed to a point 930 feet below its normal regional position. Progressively deeper in the stratigraphic series, we find evidence of increasing uplift (Table II), both centrally and on the rim.

TABLE II

	At Highest Point Between Wells 3 and 6			*In Well 8a*		
Horizon	*Measured Position Relative to Sea-Level*	*Estimated Normal Position Relative to Sea-Level*	*Indicated Movement*	*Measured Position Relative to Sea-Level*	*Estimated Normal Position Relative to Sea-Level*	*Indicated Movement*
Top Catahoula	+ 410 (Est.)	+ 210	Up 200 (?)	− 190	+ 340	Down 530
Top Jackson	+ 160	− 40	Up 200	− 840	+ 90	Down 930
Top Yegua	− 105	− 840	Up 735	− 945	− 710	Down 235
Top Cook Mountain	− 410	−1,640	Up 1,230	−1,110	−1,510	Up 400
Top Mount Selman	− 645	−2,090	Up 1,445	−1,180	−1,960	Up 780
Top Wilcox	− 920	−2,890	Up 1,970	−1,410	−2,760	Up 1,350

10. The fact that a maximum thickness of cap rock has been found in the central basin does not seem to justify the theory of solution of the salt as a cause of the down-sinking. However that may be, we should naturally expect more solution near the edges of the salt mass and on its sides than on its top, even if there were no cap present. We suggest that possibly this central basin is the result of mechanical settling of the inner part of the plug, perhaps occasioned by a relief of the compression which must have existed during its rise through, and relative to, the surrounding strata. Evidence of similar post-compression relief is almost invariably observed in the normal faulting which affects folded prisms of strata. The seeming gradual differential settling may be explained by the fact that salt, unlike most rock materials, is very plastic under unequal compression and can not accumulate strains which might eventually produce faulting.

Seemingly the presence of extensive sagging in the central part of a salt dome is not unique at Clay Creek. Another example is recorded on page 277 in the Chestnut dome in Natchitoches Parish, Louisiana.

F. H. Lahee

Dallas, Texas
February 4, 1931

GRAPHIC SOLUTION OF STRIKE AND DIP FROM TWO ANGULAR COMPONENTS

The problem of determining the true dip and strike of a plane from two apparent dips in different directions is so frequently encountered in geological work that it is quite deserving of the simplest and most nearly fool-proof method of solution that can be found. Two interesting discussions have already appeared in this section of the *Bulletin* under this title. The first, in Vol. 13, No. 9 (September, 1929), page 1211, by Mr. Kitson, suffers the disadvantage that in small-angle dips one must locate the point of intersection of two very acutely intersecting lines. This is difficult to do with a high degree of accuracy. It requires, moreover, a large drawing and very accurate draftmanship.

The second method, that of Mr. Nettleton, described in Vol. 15, No. 1 (January, 1931), page 79, is attractive for its directness and simplicity. Unfortunately, however, Mr. Nettleton has committed the very common error of assuming that *angles* when plotted graphically as vectors obey the laws of vector addition and resolution. This is, in general, not even approximately true.

The desired solution is one that, while having the simplicity of that offered by Mr. Nettleton, is rigorously correct for all angles of dip. Such a solution of this and several similar problems has been presented by A. Harker, "Graphical Methods in Field Geology," pages 154-62, *Geological Magazine* (1884). The essentials of Harker's method, with a somewhat different proof, are here presented.

In Figure 1 let *ABCD* be the plane whose strike and dip are to be considered. Let *EFG* be points on an intersecting horizontal plane. Let θ be

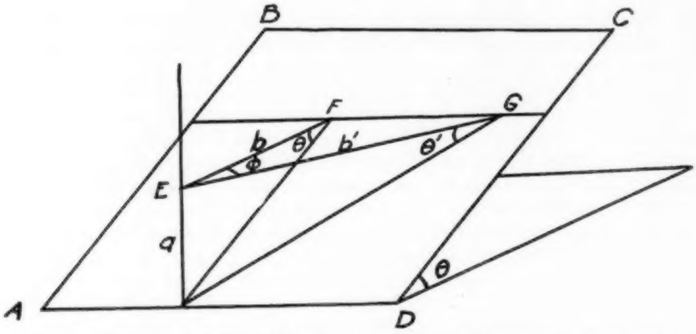

FIG. 1.—Geometrical illustration showing relation between true dip Θ and apparent dip Θ'.

the angle of true dip. Let Θ' be the angle of apparent dip in a vertical plane making an angle ϕ with the vertical plane containing the true dip.

Then in Figure 1,

$$a = b \tan \Theta = b' \tan \Theta' \tag{1}$$

and

$$b = b' \cos \phi \tag{2}$$

Substituting (2) in (1) we get,

$$b' \tan \Theta \cos \phi = b' \tan \Theta'$$

or

$$\tan \Theta' = \tan \Theta \cos \phi \tag{3}$$

Equation (3) gives the apparent dip in any direction as a function of the true dip and the angle between the true and apparent dips. Tan Θ in any given case is a constant. Since the *tangent* of the apparent dip is proportional to the *tangent* of the true dip and to the cosine of the angle between them, it follows immediately that these are vector quantities, as they obey the laws of vector resolution and addition. The solution is obvious if one knows how to resolve and compound vectors.

Given the true dip and its direction, to find the apparent dip in a direction making an angle ϕ with the direction of true dip (See Figure 2):

Lay off N.-S. and E.-W. axes. From the origin and in the direction of the true dip draw a vector whose length is proportional to the tangent of the angle of true dip. Draw another line from the origin at an angle ϕ from the true dip vector. Drop a perpendicular from the extremity of the true dip vector to this line. The line segment from the origin to this intersection is another

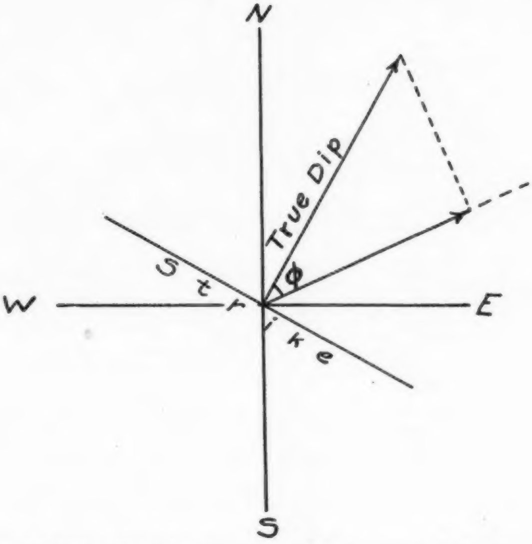

FIG. 2.—Method of obtaining the apparent dip in any given direction when true dip is known. The length of each vector is proportional to the *tangent* of the corresponding angle of dip.

vector whose length is proportional to the *tangent* of the angle of the apparent dip in this direction.

Given the angles of two apparent dips and their directions, to find the true dip and strike (see Figure 3):

Lay off N.-S. and E.-W. axes as before. From the origin draw vectors in the directions of the apparent dips. Let the lengths of these vectors be respectively proportional to the *tangents* of the angles of apparent dips. Erect perpendiculars at the extremities of each of the apparent dip vectors. From the origin to the point of intersection of these two perpendiculars draw another vector. This last is the true dip vector. Its direction is the direction of the true dip of the plane and its length is porportional to the *tangent* of the angle of the true dip.

This method is identically that of Mr. Nettleton except that he made the mistake of using vectors that were proportional to the *angles* of dip instead of to their *tangents*. His method is a good approximation only so long as the angles are small enough so that one may consider tan Θ equal to the angle Θ measured in radians. In large angles this is grossly erroneous, whereas the method outlined above is rigorously correct for all angles.

It is interesting to notice in passing that the vector solution of the above problem is only a special case of a much more general theorem of vector analysis.

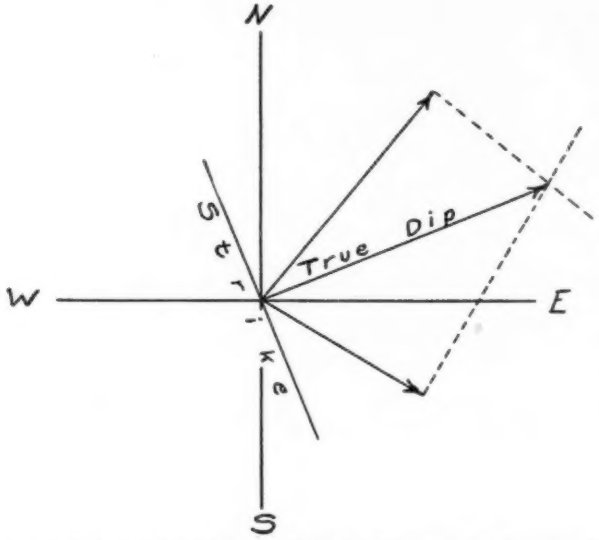

FIG. 3.—Method of obtaining true dip and strike when two apparent dips are known. The vectors again are proportional to the *tangents* of the corresponding angles of dip.

A plane scalar field is defined as a plane with each point of which there corresponds a definite scalar quantity. This scalar quantity may be density, temperature, elevation, or any one of various other properties. If this scalar field varies continuously from point to point throughout the plane, then the rate of change of the scalar quantity with distance in a given direction is called the component of the gradient of the field in that direction at the point considered. This gradient is a vector quantity and is subject to analysis by vector methods.

In the preceding problem, the horizontal plane can be thought of as a scalar field, its scalar quantity being the elevation (relative) of the corresponding point on the dipping plane. Hence, the gradient of this field is defined as the rate of change of the elevation with distance. This, in turn, is readily seen to be the tangent of the apparent dip in the direction considered.

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Instructor in geophysics

DEPARTMENT OF GEOLOGY
AND MINERALOGY
COLUMBIA UNIVERSITY, NEW YORK
January 25, 1931

RESEARCH NOTES

A. A. P. G. RESEARCH COMMITTEE

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The purpose of the research committee is the advancement of research within the field of petroleum geology. If members working actively in research on particular problems care to register with the research committee, the committee will be glad to aid them in any way it can and put them in touch with other men who are, or have been, working on similar or allied problems and can perhaps effect some integration of the research work of the Association. If the younger, or older, members of the Association, who are doing or preparing research for publication, will come to any member of the committee, he will be very glad to offer whatever advice, counsel, or criticism he can in regard to the research, its prosecution, or its preparation for formal presentation. The committee would be glad to have members formulate and present to it suggestions in regard to research problems and programs.

OUTLINE OF ASSOCIATION RESEARCH PROGRAM

The subjects here listed are to be discussed at the annual meeting of the Association in San Antonio, Texas, March 19-21, 1931, and published in Volume III of the symposium, *Structure of Typical American Oil Fields*. The plan here outlined was adopted by the research committee at its meeting of May 24, 1930, at Tulsa, Oklahoma, and was revised on January 12, 1931.

These studies should constitute an analytical review of the published data relating to the genesis and accumulation of petroleum. The discussion of these problems should include a consideration of the facts, especially those presented in Volumes I and II of the symposium on *Structure of Typical American Oil Fields*, as well as all other pertinent published or unpublished information. Definite conclusions and summaries are to be made where possible from the information available. If facts are subject to differences of interpretation, all possibilities should be enumerated and, where possible, definite suggestions offered for work necessary to be accomplished in order finally to solve such problems.

In this manner, the research committee hopes to inventory the known facts and determine the status of theories important to petroleum geology, and to establish from the results of this endeavor a definite program for future research.

1. *Introduction*
   (a) Historical Development of Structural Theory of Oil and Gas Accumulation. With Bibliography—J. V. Howell
2. *Origin*
   (a) Present Available Evidence Concerning Origin of Oil and Gas—David White
   (b) Compilation of Data Relative to Present Knowledge of Source Beds—L. C. Snider
   (c) Evidence Concerning Rôle of Bacteria in Formation of Natural Hydrocarbons—Harald E. Hammar, assisted by S. A. Waksman
   (d) Petroleum Evidences in Recent Sediments—Parker D. Trask
3. *Migration and Accumulation*
   (a) Present Interpretations of Structural Theory of Oil and Gas Migration and Accumulation—(1) John L. Rich
   (2) W. Ross Keyte
   (b) Discussion of Vertical and Lateral Migration of Oil and Gas—F. H. Lahee
   (c) Important Phenomena Concerning Oil and Gas Accumulation in Limestone—W. V. Howard
   (d) Analysis of Gas Accumulation—Henry A. Ley
4. *Interpretation of Local Structural Development in Areas Associated with Deposits of Petroleum*
   (a) Appalachian—W. A. Price
   (b) Mid-Continent—Alex. W. McCoy
   (c) Salt Domes—Marcus A. Hanna
   (d) Permian Basin of West Texas—R. L. Cannon and Joe Cannon
   (e) Rocky Mountain—Hugh A. Stewart
   (f) California—Frederick P. Vickery
5. *Interpretation and Importance of Stratigraphic Unconformities in Localities of Oil and Gas Accumulation*
   (a) Eastern United States—Leon J. Pepperberg and D. T. Ring
   (b) Mid-Continent—A. I. Levorsen
   (c) Gulf Coast—Dave P. Carlton and James A. Waters
   (d) Rocky Mountain—H. F. Davies
   (e) California—H. W. Hoots and W. D. Kleinpell
6. *Analysis of Information Relative to Carbon Ratios*
   (a) Present Knowledge—W. T. Thom, Jr.
   (b) Discussion—Charles L. Baker (title to be decided by author)

7. *Porosity, Cementation and Compaction*
    (a) Relation of Porosity and Cementation to Production of Oil and Gas—A. F. Melcher, P. G. Nutting, and Chas. R. Fettke
    (b) Importance of Compaction and Its Effect on Petroleum Accumulation—L. F. Athy

8. *Variations in Physical Properties of Petroleum Which Are Subject to Environment*
    (a) Variation of Gravity with Depth
        (1) Mid-Continent—Chas. H. Pishny
        (2) Gulf Coast—Donald C. Barton
        (3) Rocky Mountain—John Bartram
        (4) California—Paul W. Prutzman
    (b) Importance of Relation of Distribution, Sedimentation, and Paleogeographic Conditions to Character of Oil—W. C. Spooner
    (c) Characters of Oil and Origin of Differences in Various Environments—Paul Weaver
    (d) Effect of Geologic Environment on Oil as Exemplified by Hydrogenation Process—Wallace E. Pratt
    (e) Temperature Gradients—C. E. Van Orstrand

9. *Petroleum Provinces, Their General Features and Relations to Regional Geology*
    (a) Relation of Geosynclinal Basins to Development of Petroleum Provinces—R. C. Moore (title to be selected by author)
    (b) General Discussion—J. Th. Erb (title to be selected by author)
    (c) Petroleum Reservoirs—W. B. Wilson

10. *Oil Field Waters*
    (a) Eastern District—Paul D. Torrey
    (b) Mid-Continent District—L. C. Case
    (c) Gulf Coast District—H. E. Minor
    (d) Rocky Mountain District—R. Clare Coffin
    (e) California—N. L. Taliaferro
    (f) Importance of Bio-Chemical Study of Oil-Field Waters—R. L. Ginter

11. *List and Bibliography of Published Structure Maps and Cross Sections of Oil-Field Stratigraphy Published Outside the Bulletin of the American Association of Petroleum Geologists*
    (a) Eastern United States—Miss Olive C. Postley
    (b) Western United States—Miss Agnes M. Farrell

ALEX. W. MCCOY, *chairman*

BARTLESVILLE, OKLAHOMA
January 12, 1931

REVIEWS AND NEW PUBLICATIONS

Bruch und Fliess-Formen der technischen Mechanik und ihre Anwendung auf Geologie und Bergbau. Band II, *Scher Formen;* Band III, *Zerreiss Formen.* (Break and Flow Forms of Technical Mechanics and Their Application in Geology and Mining. Vol. II, Shear Forms; Vol. III, Tear Forms.) By ERICH SEIDL. (VDI Verlag, Berlin, 1930.) 22 pp., 51 text figs.; 81 pp., 145 text figs.

The general plan of each book is to describe the shear and tear forms which are obtained in the engineering test laboratory and to show how these forms can be recognized in geologic structures. The argument is based chiefly on the use of many illustrations, reproductions of photographs of the results of laboratory tests on metallic test blocks, diagrammatic sketches, reproductions of photographs of geologic outcrops, and geologic maps and cross sections of structures showing shear and tear forms. The thought is suggested that a graben or horst or both together may be formed by horizontal linear tension and that a graben at the surface may grade into a horst below, because of the fact that at the point of incipient break in a rod under tension there is constriction downward of the upper part of the rod and constriction upward of the lower part. Dependent on various conditions, the resulting geologic structure may be predominantly horst, predominantly graben, or equally graben above and horst below. The thought is used to explain the German salt domes, the structure of the Bavarian Alpine foreland, and the Great Rift valley of Africa. The study presented in these two thin books is interesting. Even a geologist who reads German with difficulty may find much of interest in a perusal of the illustrations.

The following chapters are in preparation: I, "Theoretical Introduction"; IV, "Compression Forms"; V, "Forms Produced by Bending"; VI, "Forms Produced by Flowage."

DONALD C. BARTON

HOUSTON, TEXAS
January 7, 1931

"The Louisiana Earthquake of October 19, 1930." By FRANK NEUMANN. *Eastern Section Seism. Soc. Amer.*, Vol. 2, No. 3 (December 10, 1930), pp. 1, 2.

The isoseismal map indicates that the shock originated approximately 60 miles west of New Orleans, Louisiana, and not off the coast, as is sometimes suggested. Instrumental records are not sufficient to determine the epicenter, but more than 100 reports were available on which to base the location, intensity, and extent of the shock.

The epicenter lies in the Atchafalaya bottoms between Franklin, St. Mary Parish, and Donaldsonville, Ascension Parish. The center of the area of greatest intensity is shown by Neumann as lying almost exactly midway between the Napoleonville and Whitecastle salt domes.

DONALD C. BARTON

HOUSTON, TEXAS
January, 1931

RECENT PUBLICATIONS

BRAZIL

"Oil Geology of the State of San Paolo (Brazil)," by L. F. de Moraes Rego. *Servico geologico e mineralogico do Brasil Bull. 46* (Rio de Janiero, 1930), 7¼ × 10¾ inches, 110 pp. (In Portuguese.)

CANADA

"Geology of Southern Alberta and Southwestern Saskatchewan," by M. Y. Williams and W. S. Dyer. *Canada Dept. of Mines, Geol. Survey Mem. 163* (Ottawa, 1930), 160 pp., 5 pls., 4 figs.

CHINA

"Petroleum Resources of China," *Oil News*, Vol. 28 (1930), pp. 534-5. Summary of an article by B. P. Torgasheff in the *Chinese Nation*. Abstract in *Jour. Inst. Petrol. Tech.* (London), Vol. 17, No. 87 (January, 1931), p. 1A.

GENERAL

"Earth Temperatures in Oil Fields," *Amer. Petrol. Inst. Prod. Bull. 205* (New York, 1930). 8¼ × 10¾ inches. 139 pp. Price, $1.50.

"Gas in Relation to Oil Production," by B. J. Ellis. *Jour. Inst. Petrol. Tech.* (London), Vol. 17, No. 87 (January, 1931), pp. 2-41.

National Research Council, Division of Geology and Geography, Annual Report—Year 1929-1930 (Washington, D. C.). Contains, in addition to lists of committee members, report of chairman, and minutes of annual meeting, reports of 27 committees of the Division, including the following appendices: I, "Micropaleontology," by J. A. Cushman; N, "Tectonics," by G. R. Mansfield; Exhibit A of Appendix N, abstract of the report entitled "The Gravity-Measuring Cruise of the United States Submarine S-21," by F. A. Vening Meinesz, F. E. Wright, and E. A. Lamson (abstracted by C. S. Freeman); R, "Isostasy," by William Bowie; S, "Improvement of Methods in Gravity Measurements," by William Bowie; U, "Conservation of the Scientific Results of Drilling," by W. A. Nelson; Y, "Research Committee, American Association of Petroleum Geologists," by A. W. McCoy. Appendix V, "Report of the Committee on Submarine Configuration and Oceanic Circulation," by T. Wayland Vaughan, is issued in complete form in a separate book of 134 mimeographed pages.

Entstehung, Veredlung und Verwertung der Kohle, by W. Petrascheck, H. Apfelbeck, H. Tropsch, R. Heinze, A. Czermak, E. Kothny, H. Löffler, A.

Rozinek, J. C. Breinl. (Gebrüder Borntraeger, Schöneberger Ufer 12a, Berlin W. 35, Germany, 1930.) 359 pp., illus. Price, unbound, 30 M.; bound, 33 M.

"Use of the Cable Tool Core Barrel in Recovering Samples of Oil Sands," by Paul D. Torrey. *Petroleum Engineer* (Tulsa, February, 1931), pp. 106, 108, 110, illus.

GEOPHYSICS

Handbuch der Geophysik, Band III, Lieferung 1, 570 pp. 207 illus. "Kräfte in der Erdkruste," by B. Gutenberg; "Plutonismus und Vulkanismus," by F. von Wolff; "Erdkrustenbewegungen," by A. Born; "Geotektonische Hypothesen," by B. Gutenberg; "Mechanische Wirkungen von Eis auf die Erdkruste," by H. Hess. (Gebrüder Borntraeger, Berlin, 1930.) Subscription price, 48 M.

"Geophysical Prospecting in 1930 Obtained Many Significant Results," by Donald H. McLaughlin. *Oil and Gas Jour.* (Tulsa, Oklahoma, January 22, 1931), pp. 78, 80.

"Anomalies of Vertical Intensity. Correlation of the Anomalies of Vertical Intensity of the Earth's Magnetic Field with the Regional Geology of North America," by George B. Somers. *Colorado Sch. of Mines Mag.* (Golden, Colorado, August, September, October, November, and December, 1930, and January and February, 1931), 63 pp., 2 illus. Available in reprint form.

KENTUCKY

The Legrande Oil Pool, by Willard Rouse Jillson. (The State Journal Company, Frankfort, Kentucky, 1930.) 103 pp., 31 illus.

"Geological Survey Affairs," by Willard Rouse Jillson. *Kentucky Geological Survey*, Series VI, Vol. 35 (Frankfort, Kentucky, 1930). Includes "Geology of the Island Creek Oil Pool." 375 pp., 140 illus.

"Natural Gas Sands of Western Kentucky," by W. R. Jillson. Correlation chart based on actual records for every important gas field. Correlation datum: top of Devonian black shale, top of Cypress Chester Mississippian sandstone, and base of Pennsylvanian Caseyville Pottsville sandstone. *Kentucky Geol. Survey*, Ser. VI (1931). Single sheet. Size, 26½ × 37 inches.

THE ASSOCIATION LIBRARY

Headquarters acknowledges the following library accessions.

MISSOURI AND ILLINOIS

From U. R. Laves:

Fauna of the Kimmswick Limestone of Missouri and Illinois, by John H. Bradley, Jr. Contrib. Walker Mus., Vol. II, No. 6. (Univ. of Chicago Press, 1930).

UTAH

From U. R. Laves:

The Lower Triassic Cephalopod Fauna of the Fort Douglas Area, Utah, by Asa A. L. Mathews. Walker Mus. Mem., Vol. I, No. 1. (Univ. of Chicago Press, 1929).

THE ASSOCIATION ROUND TABLE

MEMBERSHIP APPLICATIONS APPROVED FOR PUBLICATION

The executive committee has approved for publication the names of the following candidates for membership in the Association. This does not constitute an election, but places the names before the membership at large. If any member has information bearing on the qualifications of these nominees, he should send it promptly to J. P. D. Hull, business manager, Box 1852, Tulsa, Oklahoma. (Names of sponsors are placed beneath the name of each nominee.)

FOR ACTIVE MEMBERSHIP

Geoffrey Barrow, Maracaibo, Venezuela, S. A.
J. B. Burnett, E. C. Reed, C. P. Bong
Levi Stanley Brown, Austin, Tex.
E. H. Sellards, Hal P. Bybee, Fred M. Bullard
William T. Foran, Tulsa, Okla.
L. Murray Neumann, E. O. Markham, D. C. Nufer
Enrico Fossa-Mancini, Buenos Aires, Argentina, S. A.
Eugene Stebinger, H. E. Althaus, F. A. Sutton
Konstanty Tolwinski, Boryslaw, Poland
W. P. Haynes, Harold F. Crooks, Ray P. Walters
Stanislav Zuber, Lwow, Poland
Ed Bloesch, W. van Holst Pellekaan, W. E. Wrather

FOR ASSOCIATE MEMBERSHIP

Julian D. Barksdale, Tampico, Tamps., Mex.
L. C. Snider, Linn M. Farish, H. M. Kirk
Eugene Field Boehms, San Angelo, Tex.
Hal P. Bybee, R. L. Cannon, E. H. Sellards
Herbert A. Hemphill, San Angelo, Tex.
Hal P. Bybee, E. H. Sellards, R. E. Rettger
Barton Walker Moore, Ardmore, Okla.
A. W. Weeks, Julian Q. Myers, F. W. Bartlett
Lee Cherry Smith, Tyler, Tex.
Wallace C. Thompson, H. J. McLellan, E. A. Wendlandt
José Terragona, Buenos Aires, Argentina, S. A.
Eugene Stebinger, F. A. Sutton, Campbell M. Hunter

FOR TRANSFER TO ACTIVE MEMBERSHIP

Gage Lund, Midland, Tex.
Leonard W. Orynski, Roy Lebkicher, Herman F. Davies
Raymond Sidwell, Lubbock, Tex.
Leroy T. Patton, W. I. Robinson, M. A. Stainbrook

James Hiram Tandy, Tulsa, Okla.
Robert E. Garrett, H. M. Scott, E. F. Shea

GEOLOGICAL SOCIETY OF AMERICA ANNUAL MEETING TULSA, DECEMBER 29-31, 1931

The Geological Society of America has chosen Tulsa for its 1931 annual meeting, to be held December 29, 30, and 31, and has invited The American Association of Petroleum Geologists to meet jointly with it.

The Mayo Hotel, with ample accommodations for all activities, will be headquarters for all technical sessions and the annual smoker and dinner will be held there. In addition to the Mayo, the other hotels in the city will provide accommodations for all visiting geologists who wish to attend this meeting.

Field trips will be arranged to study special features of the geology and oil fields of Oklahoma. These trips will be taken December 28 and January 1-4. They will include Spavinaw, the Ozark Mountains, the Arbuckle Mountains, the Wichita Mountains, the Ouachita Mountains, the Oklahoma City oil field and the surface structural conditions of the famous Cushing oil field.

The membership in the Geological Society of America is approximately 600, and the membership of The American Association of Petroleum Geologists is 2,540. The Tulsa Geological Society will be host to this joint meeting in Tulsa. The local geological societies, Tulsa, Oklahoma City, Shawnee, and Ardmore, will be hosts to this joint meeting for the field trips.

Frank R. Clark, of the Mid-Kansas Oil and Gas Company, Tulsa, Oklahoma, will act as general chairman for all local arrangements of the Tulsa meeting. Communications of all kinds should be addressed to him.

General arrangements for the Geological Society of America will be in charge of Professor Charles P. Berkey, Secretary, Columbia University, New York City.

The officers of the Geological Society of America are: president, Alfred C. Lane, Tufts College, Boston, Massachusetts; vice-presidents, Thomas L. Walker, Toronto, Canada, Henry B. Kummel, Trenton, New Jersey, E. R. Cummings, Indiana University, Bloomington, Indiana, Alexander H. Phillips, Princeton, New Jersey; secretary, Charles P. Berkey, Columbia University, New York City; treasurer, Edward B. Mathews, Johns Hopkins University, Baltimore, Maryland.

FINANCIAL STATEMENT, 1930

WILLSON & GARNETT, CERTIFIED PUBLIC ACCOUNTANTS,
Kennedy Building, Tulsa, Oklahoma, January 27, 1931.

EXECUTIVE COMMITTEE OF
THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
MR. SIDNEY POWERS, President
Tulsa, Oklahoma

GENTLEMEN:

In accordance with your instructions, we have made an examination of the books and records of The American Association of Petroleum Geologists, Tulsa, Oklahoma, for the year ended December 31, 1930. We herewith submit our report with Exhibits and Schedules as follows.

Exhibit A—Statement of Financial Condition as at December 31, 1930
Exhibit B—Statement of Income and Expenditures for the year ended December 31, 1930
Exhibit C—Comparative statement of Income and Expense
Schedule 1—Inventory of Printed Matter
Schedule 2—Investments
Schedule 3—Cost of Printed Matter Sold
Schedule 4—Loss on Sale of Investments

Scope of examination.—Cash receipts and disbursements were checked in detail. Cash receipts were traced to the respective depositories and cash disbursements were found to be supported by properly cancelled checks in your files. The balance of cash in banks was reconciled to amounts certified to by letters from the depositories and is composed as follows.

First National Bank		
Principal Account	$7,886.79	
National Bank of Commerce		
Operating Account	492.25	
Total General Fund		$8,379.04
First National Bank		
Publication Fund		200.73
Total Cash in Banks		$8,579.77

Invoices supporting disbursements were examined to satisfy us as to the accuracy of distributions, which, in our opinion, have been properly recorded. However, no detailed analysis of expense accounts was made.

Postings to general ledger accounts were sufficiently tested and no errors were disclosed.

Bonds and Investment Certificates listed in Schedule 2 were examined and found to be regular. All unmatured interest coupons were attached thereto. The Funds deposited in Morris Plan Company 5 per cent savings accounts were verified by letter from the Morris Plan Company.

At your request we have included in Schedule 2 the market value of securities at December 31, 1930. The amounts included are based on quotations furnished by your office which have not been verified by us.

The market value of investments in the Morris Plan Company is par and accrued interest which has been verified by letter from the Morris Plan Company.

Investments in securities of the Exchange National Company and the Exchange Trust Company are redeemable at par if held to maturity. If redeemed prior to

maturity, an adjustment of interest is made and deducted from the face of the security. We have listed these securities at par in accordance with letter from the Exchange Trust Company.

Your membership records were examined and delinquencies were disclosed as follows.

1929 Membership Dues		
15 Active Members at $15.00	$225.00	
1 Active Member balance due	10.00	
		$235.00
15 Associate Members at $10.00		150.00
		$385.00
1930 Membership Dues		
85 Active Members at $15.00	$1,275.00	
1 Active Member overpaid	1.00	
		$1,274.00
49 Associate Members at $10.00	$ 490.00	
1 Associate Member balance due	2.00	492.00
Total Accounts Receivable		$2,151.00

Comments.—Physical inventory of printed matter on hand was made by our representative with the assistance of your office. Quantities on hand have been valued at actual cost of printing exclusive of editorial and other expenses of compiling. Damaged and unsalable printed matter has been excluded from the inventory.

Interest earned on investments has been accrued to December 31, 1930, as set out in Schedule 2.

All known accounts payable as at December 31, 1930, have been recorded.

No provision has been made for doubtful accounts receivable as we were advised that all accounts considered uncollectible have been charged off currently.

Depreciation of Furniture and Fixtures has been computed for the period under review.

Adjusting entries to bring the books into agreement with this report will be furnished under separate cover.

Certificate.—*We Hereby Certify* that, in our opinion, and subject to the foregoing comments, the statement of Financial Condition and statement of Income and Expenditures, submitted herewith reflect, respectively, the financial condition of The American Association of Petroleum Geologists as at the close of business, December 31, 1930, and the results of its operations for the year then ended.

Respectfully submitted,

(Signed) WILLSON & GARNETT
Certified Public Accountants

EXHIBIT A

STATEMENT OF FINANCIAL CONDITION AS AT DECEMBER 31, 1930

ASSETS

	General Fund	Publication Fund	Research Fund	Total
CURRENT ASSETS				
Cash in banks				
First National Bank	$ 7,886.79	$ 200.73		$ 8,087.52
National Bank of Commerce	492.25			492.25
Accounts receivable				
Active Members (see letter)	1,509.00			1,509.00
Associate Members (see letter)	642.00			642.00
General Fund Suspense		27.00		27.00
Advertising	714.00			714.00
Inventories (Schedule 1)	15,665.69	5,455.36		21,121.05
Accrued Interest	483.09	87.66	1.10	571.85
Total Current Assets	$27,392.82	$ 5,770.75	$ 1.10	$33,164.67
INVESTMENTS				
Bonds and Savings Certificates (Sch. 2)	$26,658.20	$ 9,770.55	$ 696.32	$37,125.07
Life Membership Fund (Sch. 2)	600.00			600.00
Total Investments	$27,258.20	$ 9,770.55	$ 696.32	$37,725.07
FIXED ASSETS				
Furniture and Fixtures	$ 3,059.80			$ 3,059.80
PREPAID EXPENSE				
Insurance	$ 93.89			$ 93.89
TOTAL ASSETS	$57,804.71	$15,541.30	$ 697.42	$74,043.43

LIABILITIES AND SURPLUS

	General Fund	Publication Fund	Research Fund	Total
CURRENT LIABILITIES				
Due Publication Fund	$ 27.00			$ 27.00
Accounts Payable	2,345.74			2,345.74
Total Current Liabilities	$ 2,372.74			$ 2,372.74
DEFERRED INCOME				
1931 Active Membership Dues	4,725.00			4,725.00
1931 Associate Membership Dues	1,160.00			1,160.00
1932 Active Membership Dues	15.00			15.00
1931 Subscriptions	1,919.75			1,919.75
Total Deferred Income	$ 7,819.75			$ 7,819.75
RESERVES				
Reserve for Depreciation	$ 859.77			$ 859.77
SURPLUS				
January 1, 1930	$46,687.48	$ 4,999.51	$ 403.86	$52,090.85
Adjustments	708.19			708.19
	$45,979.29	$ 4,999.51	$ 403.86	$51,382.66
Net Income for Year 1930	773.16	10,541.79	293.56	11,608.51
Total Surplus	$46,752.45	$15,541.30	$ 697.42	$62,991.17
TOTAL LIABILITIES AND SURPLUS	$57,804.71	$15,541.30	$ 697.42	$74,043.43

EXHIBIT B

STATEMENT OF INCOME AND EXPENDITURES FOR YEAR ENDED DECEMBER 31, 1930

	General Fund		*Publication Fund*		*Research Fund*	*Total*
INCOME						
Dues						
Active Memberships	$26,217.50					
Associate Memberships	7,520.00					
Subscriptions	4,205.32	$37,942.82				$37,942.82
Income from Bulletins						
Sales of Bound Volumes	$ 4,704.50					
Sales of Index	101.80					
Sales of Numbers and Separates	1,178.45					
Advertising	7,233.14					
Miscellaneous	115.65	13,333.54		$ 23.74		13,357.28
Sales of Publications						
Theory of Continental Drift			$ 404.00			
Structure of Typical American Oil Fields.						
Volume I			2,279.19			
Volume II			6,562.51	9,245.70		9,245.70
Other Income						
Interest Earned	$ 1,915.30		$ 226.80		$ 33.56	2,175.66
Convention Receipts (incl. $450 of 1931)	2,000.00					2,000.00
Received from General Fund			2,579.72			2,579.72
Donations		3,915.30	5,365.00	8,171.52	260.00	5,625.00
TOTAL INCOME FROM OPERATIONS		$55,191.66		$17,440.96	$ 293.56	$72,926.18
EXPENDITURES						
Cost of Printed Matter Sold (Schedule 3)	$29,332.26		$ 6,648.40			
Manager's Salary	7,500.00					
Clerical Salaries	6,212.61					
Rent	93.00					
Printing and Office Supplies	2,250.69					
Postage	1,210.58					
Exchange and Refunds	66.42					
Telephone and Telegraph	325.28					
Executive Expense	68.89					
Traveling Expense	124.16					
Auditing and Legal Expense	521.58					
Convention Expense	1,878.89					
Advertising Commissions and Discount	498.09					
Contributed to Society of E. P. & M.	1,000.00					
Contributed to National Research Council, Bibliography of Economic Geology	50.00					
Miscellaneous	61.28		80.77			
Insurance	246.75					
Depreciation	289.55					
Loss on Sale of Investments (Schedule 4)	108.75		170.00			
Transferred to Publication Fund for Struc. Vol. II	2,579.72					
TOTAL EXPENDITURES		54,418.50		6,899.17		61,317.67
NET INCOME		$ 773.16		$10,541.79	$ 293.56	$11,608.51

EXHIBIT C

COMPARATIVE STATEMENT OF INCOME AND EXPENSE

GENERAL FUND

	1929	*1930*	*Increase or Decrease*
INCOME			
Dues			
Life Memberships	$ 600.00		$ −600.00
Active Memberships	23,972.00	26,217.50	2,245.50
Associate Memberships	6,848.00	7,520.00	672.00
Subscriptions	4,146.53	4,205.32	58.79
Income from Bulletins			
Sales of Bound Volumes	3,605.20	4,704.50	1,099.30
Sales of Index	399.04	101.80	−297.24
Sales of Numbers and Separates	858.40	1,178.45	320.05
Sale of Salt Dome Volume (Edition exhausted in 1929)	734.66		−734.66
Advertising	6,973.95	7,233.14	259.19
Miscellaneous	121.05	115.65	−5.40
Other Income			
Interest Earned	1,919.36	1,915.30	−4.06
Convention Receipts		2,000.00	2,000.00
TOTAL INCOME	$50,178.19	$55,191.66	$ 5,013.47
EXPENSES			
Cost of Printed Matter Sold (Bulletins)	$25,860.86	$29,332.26	$ 3,471.40
Manager's Salary	7,500.00	7,500.00	
Clerical Salaries	3,979.31	6,212.61	2,233.30
Rent		93.00	93.00
Printing and Office Supplies	1,294.07	2,250.69	956.62
Postage	1,316.96	1,210.58	−106.38
Exchange and Refunds	62.45	66.42	3.97
Telephone and Telegraph	296.47	325.28	28.81
Executive Expense	11.85	68.89	57.04
Traveling Expense	286.75	124.16	−162.59
Auditing and Legal	491.50	521.58	30.08
Convention Expense	494.33	1,878.89	1,384.56
Advertising Commissions and Discount	70.70	498.09	427.39
Contributions	1,050.00	1,050.00	
Miscellaneous	115.35	61.28	−54.07
Insurance	267.21	246.75	−20.46
Depreciation	244.01	289.55	45.54
Loss on Sale of Investments		108.75	108.75
Transfer to Publication Fund for Struc. Vol. II		2,579.72	2,579.72
TOTAL EXPENSE	$43,341.82	$54,418.50	$11,076.68
NET INCOME	$ 6,836.37	$ 773.16	−6,063.21

SCHEDULE I

INVENTORY OF PRINTED MATTER AS AT DECEMBER 31, 1930

GENERAL FUND

BULLETINS (PAPER COVERS)		Number of Copies	Unit Cost	Value
Vol. 2		145	$1.15	$ 166.75
Vol. 3		70	1.80	126.00
Vol. 4	No. 2	20	1.13	22.60
	No. 3	33	1.13	37.29
Vol. 5	No. 2	114	.90	102.60
	No. 3	194	.37	71.78
	No. 4	203	.30	60.90
	No. 5	159	.40	63.60
	No. 6	53	.32	16.96
Vol. 6	No. 1	3	.29	.87
	No. 2	79	.39	30.81
	No. 3	188	.40	75.20
	No. 4	173	.37	64.01
	No. 5	229	.35	80.15
	No. 6	220	.29	63.80
Vol. 7	No. 1	220	.61	134.20
	No. 2	86	.60	51.60
	No. 3	34	.55	18.70
	No. 4	110	.66	72.60
	No. 5	102	.63	64.26
	No. 6	57	.64	36.48
Vol. 8	No. 1	247	.68	167.96
	No. 3	139	.79	109.81
	No. 4	170	.65	110.50
	No. 5	282	.69	194.58
	No. 6	218	.89	194.02
Vol. 9	No. 1	67	.82	54.94
	No. 2	56	1.38	77.28
	No. 3	59	1.27	74.93
	No. 4	104	.49	50.96
	No. 5	93	.39	36.27
	No. 6	90	.49	44.10
	No. 7	133	.42	55.86
	No. 8	125	.56	70.00
	No. 9	143	.44	62.92
Vol. 10	No. 1	92	.39	35.88
	No. 2	41	.49	20.09
	No. 3	92	.64	58.88
	No. 4	147	.38	55.86
	No. 5	146	.34	49.64
	No. 6	181	.39	70.59
	No. 7	199	.35	69.65
	No. 8	148	.28	41.44
	No. 9	216	.35	75.60
	No. 10	162	.38	61.56
	No. 11	98	.54	52.92
	No. 12	125	.58	72.50
Vol. 11	No. 4	9	.32	2.88
	No. 5	29	.39	11.31
	No. 6	91	.37	33.67

GENERAL FUND—*Continued*

	No. 8	48	.44	21.12	
	No. 9	28	.45	12.60	
	No. 10	41	.34	13.94	
	No. 11	71	.37	26.27	
	No. 12	13	.50	6.50	
Vol. 12	No. 3	15	.43	6.45	
	No. 4	20	.41	8.20	
	No. 5	16	.48	7.68	
	No. 6	24	.36	8.64	
	No. 7	65	.39	25.35	
	No. 8	62	.36	22.32	
	No. 9	112	.35	39.20	
	No. 10	80	.35	28.00	
	No. 11	87	.35	30.45	
	No. 12	62	.35	21.70	
Vol. 13	No. 1	270	.36	97.20	
	No. 2	279	.36	100.44	
	No. 3	339	.36	122.04	
	No. 4	325	.38	123.50	
	No. 5	353	.38	134.14	
	No. 6	319	.50	159.50	
	No. 7	339	.57	193.23	
	No. 8	320	.67	214.40	
	No. 9	344	.50	172.00	
	No. 10	315	.58	182.70	
	No. 11	382	.36	137.52	
	No. 12	349	.42	146.58	
Vol. 14	No. 1	207	.41	84.87	
	No. 2	170	.46	78.20	
	No. 3	223	.46	102.58	
	No. 4	211	.43	90.73	
	No. 5	338	.47	158.86	
	No. 6	331	.46	119.16	
	No. 7	294	.46	135.24	
	No. 8	301	.46	138.46	
	No. 9	321	.47	150.87	
	No. 10	320	.43	137.60	
	No. 11	291	.41	119.31	
	No. 12	330	.44	145.20	$ 6,900.51
CLOTH-BOUND VOLUMES					
Vol. 5		66	4.02	$ 265.32	
Vol. 6		2	3.41	6.82	
Vol. 7		3	4.38	13.14	
Vol. 8		1	5.35	5.35	
Vol. 9		3 (Sets)	3.99	11.97	
Vol. 10		14 (Sets)	3.59	50.26	
Vol. 11		182 (Sets)	3.36	611.52	
Vol. 12		260 (Sets)	6.28	1,632.80	
Vol. 13		354 (Sets)	7.34	2,598.36	$ 5,195.54
INDEX I-X INCL.		1812	1.97	$ 3,569.64	$ 3,569.64
TOTAL, GENERAL FUND					$15,665.69

PUBLICATION FUND

THEORY OF CONTINENTAL DRIFT	116	1.97	$ 228.52	$ 228.52
STRUCTURE OF TYPICAL AMERICAN OIL FIELDS				
Vol. I	564	2.91	$ 1,641.24	
Vol. II	996	3.60	3,585.60	5,226.84
TOTAL, PUBLICATION FUND				$ 5,455.36

SCHEDULE 2

INVESTMENTS AS AT DECEMBER 31, 1930

	Market Value	*Cost*	*Par Value*	%	*Interest Accrued*
GENERAL FUND—BONDS					
Allied Owners Corporation....	$ 1,565.00	$ 1,980.00	$ 2,000.00	5	$ 60.00
Argentine Gov't External Loan	937.50	997.50	1,000.00	6	10.00
Exchange Nat'l Co. Part. Certf.	500.00	500.00	500.00	5½	9.17
Exchange Trust Co. R. E. Savings................	1,100.00	1,100.00	1,100.00	5½	30.25
Hardin Co., Texas—Road	984.20*	984.20	1,000.00	5	11.11
Imperial Japanese Gov't......	515.00	462.50	500.00	6½	26.14
Indiana Hydro-Elec. Corp....	2,700.00	2,910.00	3,000.00	5	25.00
Nevada-Cal. Electric Corp....	2,707.50	2,865.00	3,000.00	5	37.50
Northern States Power Co.....	1,575.00	1,493.25	1,500.00	6	15.00
Pondera Co., Mont., Refunding	1,000.00*	1,000.00	1,000.00	5½	27.50
Public Service Co. of Okla....	1,880.00	1,980.00	2,000.00	5	33.34
United States Rubber Co.....	720.00	859.50	1,000.00	5	25.00
Abitibi Lgt. & Paper Co......	1,400.00	1,740.00	2,000.00	5	8.34
Goodyear Tire & Rubber Co..	1,762.50	1,855.00	2,000.00	5	16.66
Central Public Serv. Co.......	750.00	965.00	1,000.00	5½	45.92
The Texas Corp. Conv. Deb. .	1,012.50	1,017.50	1,000.00	5	12.50
Swift & Company...........	997.50	1,008.75	1,000.00	5	16.66
Pure Oil Company...........	2,752.50	2,940.00	3,000.00	5½	55.00
TOTAL, GENERAL FUND	$24,859.20	$26,658.20	$27,600.00		$ 465.09
LIFE MEMBERSHIP FUND					
Morris Plan Co. of Okla.—Certificates............	$ 600.00	$ 600.00	$ 600.00	6	$ 18.00
TOTAL, LIFE MEMBERSHIP FUND	$ 600.00	$27,258.20	$ 600.00		$ 483.09
PUBLICATION FUND—BONDS					
Midwest Utilities Co.........	$ 2,778.75	$ 2,919.30	$ 3,000.00	5	$ 12.50
National Dairy Products Co. .	996.25	996.25	1,000.00	5¼	21.88
Phillips Petroleum Co........	1,755.00	1,937.50	2,000.00	5¼	8.75
Swift & Company	1,995.00	2,017.50	2,000.00	5	41.67
Morris Plan Co. of Okla.—Savings	1,900.00	1,900.00	1,900.00	5	2.86
TOTAL, PUBLICATION FUND.....	$ 9,425.00	$ 9,770.55	$ 9,900.00		$ 87.66
RESEARCH FUND—CERTIFICATES					
Morris Plan Co. of Okla.—Certificates............	$ 600.00	$ 600.00	$ 600.00	6	$ .90
Morris Plan Co. of Okla.—Savings	96.32	96.32	96.32	5	.20
TOTAL, RESEARCH FUND.......	$696.32	$ 696.32	$ 696.32		$ 1.10
TOTAL, INVESTMENTS............	$35,580.52	$37,725.07	$38,796.32		$ 571.85

*Market value of Hardin Co., Texas, and Pondera Co., Montana, bonds unknown, therefore listed at cost.

SCHEDULE 3

COST OF PRINTED MATTER SOLD AS AT DECEMBER 31, 1930

GENERAL FUND (BULLETINS)				
Inventory January 1, 1930				$14,711.97
Cost of Printing Volume 14, 1930 4,000 copies monthly: 3,100 in paper covers; 900 for cloth binding				
January	No. 1	$ 1,643.71		
February	No. 2	1,823.50		
March	No. 3	1,828.80		
April	No. 4	1,705.50		
May	No. 5	1,895.00		
June	No. 6	1,823.50		
July	No. 7	1,823.50		
August	No. 8	1,809.10		
September	No. 9	1,848.50		
October	No. 10	1,705.50		
November	No. 11	1,609.15		
December	No. 12	1,752.00	$21,267.76	
Editorial Secretary—Salary and Expense			3,998.04	
Engraving			2,006.10	
Cloth Binding Vol. 13, 1929 (907 volumes)			1,632.60	
Packing and Mailing Bound Volume 13			299.15	
Stencil Corrections, Wrapping and Mailing (Vol. 14)			481.66	
Printing Separates—Chiefly authors' separates furnished gratis to authors			593.93	
Miscellaneous			6.74	
TOTAL COST DURING YEAR				30,285.98
				$44,997.95
Inventory December 31, 1930 (see letter)				15,665.69
COST OF PRINTED MATTER SOLD (GENERAL FUND)				$29,332.26
PUBLICATION FUND				
Inventory January 1, 1930			$ 2,281.16	
Expense of Symposium Volume II			9,822.60	$12,103.76
Inventory December 31, 1930 (see letter)				5,455.36
COST OF PRINTED MATTER SOLD (PUBLICATION FUND)				$ 6,648.40

SCHEDULE 4

LOSS ON SALE OF INVESTMENTS FOR YEAR ENDED DECEMBER 31, 1930

	Cost	*Selling Price*	*Profit or Loss*
GENERAL FUND			
Pure Oil Company 5½% Bonds	$2,960.00	$2,973.75	$ 13.75
Sinclair Consolidated Oil Corporation Bond	998.75	1,000.00	1.25
Skelly Oil Company Bond	931.25	807.50	−123.75
	$4,890.00	$4,781.25	$−108.75
PUBLICATION FUND			
Skelly Oil Company Bond	$ 967.50	$ 797.50	$−170.00
	$5,857.50	$5,578.75	$−278.75

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS MEMBERSHIP LIST

March 1, 1931

HONORARY MEMBERS

The executive committee may from time to time elect as honorary members persons who have contributed distinguished service to the cause of petroleum geology. Honorary members shall not be required to pay dues.—*Sec. 6, Article III, of the Constitution.*

LIFE MEMBERS

The executive committee may grant life membership to members who have paid their dues and are otherwise qualified.—*Sec. 2, Article III, of the Constitution.*

On the payment of three hundred dollars ($300.00) any member in good standing shall be declared a life member and thereafter shall not be required to pay annual dues.—*Sec. 3, Article I, of the By-Laws.*

MEMBERS

Any person engaged in the work of petroleum geology or in research pertaining to petroleum geology or technology is eligible to active membership, provided he is a graduate of an institution of collegiate standing, in which institution he has done his major work in geology, or in sciences fundamental to petroleum geology, and in addition has had the equivalent of three years' experience in petroleum geology or in the application of these other sciences to petroleum geology or to research in petroleum geology or technology; and provided further that in the case of an applicant for membership who has not had the required collegiate or university training, but whose standing in the profession is well recognized, he shall be admitted to membership when his application shall have been favorably and unanimously acted upon by the executive committee; and provided further that these requirements shall not be construed to exclude teachers and research workers in recognized institutions whose work is of such character as in the opinion of the executive committee shall qualify them for membership.

Active members alone shall be known as members.—*Sec. 1, Article III, of the Constitution.*

ASSOCIATES

Any person having completed as much as thirty hours of geology (an hour shall here be interpreted as meaning as much as sixteen recitation or lecture periods of one hour each, or the equivalent in laboratory) in a reputable institution of collegiate or university standing, or who has done field work equivalent to this, is eligible to associate membership, provided at the time of his application for membership he shall be engaged in geological studies in an institution of collegiate or university standing, or shall be engaged in petroleum geology; and any person who is a graduate of an institution of collegiate standing in which he has done his major work in sciences fundamental to petroleum geology or petroleum technology, and who has the equivalent of one year's experience in the application of his science to the study of petroleum geology, shall be eligible to associate membership, provided at the time of his application for membership he shall be engaged in investigations in the broader subject of petroleum geology and technology.

Associate members shall be known as associates.

Associates shall enjoy all the privileges of membership in the Association, save that they shall not hold office, sign applications for membership, or vote; neither shall they have the privilege of advertising their affiliation with the Association in professional cards or professional reports or otherwise.—*Sec. 3, Article III, of the Constitution.*

HONORARY MEMBERS

(**Deceased)

Decker, Charles E., 508 Chautauqua Ave., Norman, Okla.
**Dumble, E. T.
Goodrich, Harold B., 1628 S. Cincinnati, Tulsa, Okla.
Hill, Robert T., Hotel Commodore, Los Angeles, Calif.
Orcutt, W. W., Union Oil Company Bldg., Los Angeles, Calif.
**Salisbury, R. D.
Smith, George Otis, Federal Power Commission, Interior Bldg., Washington, D. C.
Udden, Johan August, 801 W. Thirty-First St., Austin, Tex.
**von Höfer, Hans Hofrat
White, David, U. S. Geological Survey, Washington, D. C.
**White, I. C.

COMPLETE LIST OF MEMBERS, ASSOCIATES, HONORARY MEMBERS, AND LIFE MEMBERS

Honorary	7
Life	2
Members	1,846
Associates	707
Total	2,562

||Abbott, John L., Texas Pacific Coal & Oil Co., Box 511, Carlsbad, N. Mexico....'27
||Abell, George T., Midland, Tex....'29
Abraham, Arthur W., Box 1466, Bakersfield, Calif....'30
Abrahamson, H., 1111 W. Fifth St., Fort Worth, Tex....'18
Abramovich, Michael, 2 Maligin St., Baku, U. S. S. R....'29
Abruns, Harry W., 303 Banks Huntley Bldg., Los Angeles, Calif....'27
||Absher, Kenneth B., Box 543, Wichita, Kan....'25
Absher, William F., Empire Gas & Fuel Co., Geological Dept., Bartlesville, Okla...'20
Ackers, A. L., Southern Crude Oil Purchasing Co., Box 128, Midland, Tex....'25
||Adams, Elmo W., 1118 de la Vina, Santa Barbara, Calif....'30
Adams, Frank C., The Texas Co., Houston, Tex....'27
Adams, George I., University of Alabama, Tuscaloosa, Ala....'21
Adams, H. H., 415 W. T. Waggoner Bldg., Fort Worth, Tex....'19
Adams, John Emery, Drawer R, Midland, Tex....'29
||Adams, Theodore F., Kappa Sigma House, Golden, Colo....'29
Adams, W. C., Deep Rock Oil Corp., Atlas Life Bldg., Tulsa, Okla....'24
Addison, Carl C., 515 Lougheed Bldg., Calgary, Alta., Canada....'30
Adkins, W. S., Bureau of Economic Geology, University of Texas, Austin, Tex....'20
Adler, Joseph L., 135 Agate St., Houghton, Mich....'30
Aguerrevere, Pedro I., Sur 3, No. 94, Caracas, Venezuela, S. A....'24
Aguerrevere, Santiago E., Sur 3, No. 94, Caracas, Venezuela, S. A....'24
Aid, Herbert, Box 737, Fort Worth, Tex....'28
Aimer, James D., Drawer 1731, Shreveport, La....'26
Ainsworth, David, 604 N. Fountain Ave., Wichita, Kan....'23
Ainsworth, William L., 301 N. Yale St., Wichita, Kan....'21
Albertson, Maurice M., Shell Petroleum Corp., Box 1672, Dallas, Tex....'20
||Alcalá, José G., Ave. Insurgentes 490, Mexico City, Mexico....'29
Aldrich, G. Frank, 2024 Wilshire Blvd., Fort Worth, Tex....'25
||Aldridge, Mort B., Ramsey Petr. Corp., 18th Floor Petroleum Bldg., Oklahoma City, Okla....'27
||Alexander, C. I., Box 192, T. C. U., Fort Worth, Tex....'27
Allan, John Andrew, University of Alberta, Edmonton, Alta., Canada....'30
Allan, Thomas H., Box 362, Russell, Kan....'24
Allen, Bryant, Box 12, Laredo, Tex....'25

*Honorary member. †Life member. ||Associate. Members are not marked. The year refers to date of election to the Association, not necessarily to class of membership.

Allen, Devere F., 1423 S. Park St., San Angelo, Tex. . . . . '29
Allen, Donald M., c/o R. F. Allen, Vian, Okla. . . . . '24
Allen, E. G., Shell Petroleum Corp., Box 1672, Dallas, Tex. . . . . '17
Allen, Walter J., Box 2203, Tulsa, Okla. . . . . '18
Allison, A. P., Box 81, Lufkin, Tex. . . . . '21
Althaus, H. E., Astra Romana, Campina, Roumania . . . . . '28
Ambrose, A. W., Empire Gas & Fuel Co., Bartlesville, Okla. . . . . '19
Ames, Edward W., Box 455, Marshall, Tex. . . . . '19
Ames, E. R., 6008 Meridian St., Los Angeles, Calif. . . . . '24
Anderson, Amil A., 721-22 Union Natl. Bank Bldg., Wichita, Kan. . . . . '22
Anderson, Carl B., 941 Kennedy Bldg., Tulsa, Okla. . . . . '19
Anderson, Frank M., 58 Hillcrest Road, Berkeley, Calif. . . . . '24
Anderson, G. E., 645 Lahoma, Norman, Okla. . . . . '24
Anderson, J. G., Jr., Box 8, Caldwell, Tex. . . . . '21
Anderson, J. L., Cia. de Petroleo de Angola, Caixa Postal 315, Loanda, Angola, Africa . . . . . '29
Anderson, Lyman P., 1518 W. Twenty-Ninth St., Oklahoma City, Okla. . . . . '27
Anderson, Warren D., Box 832, San Angelo, Tex. . . . . '27
Andreen, Harry M., Box 2045, Tulsa, Okla. . . . . '27
||Andrews, Hugh, Stratford, Okla. . . . . '30
Andrews, Philip, Box 493, Boulder, Colo. . . . . '25
Andrews, Sylvan H., 421 Philcade Bldg., Tulsa, Okla. . . . . '20
||Angle, W. M., 640 N. Park, Shawnee, Okla. . . . . '30
Apfel, Earl T., Geol. Dept., Syracuse University, Syracuse, N. Y. . . . . '29
Applin, Paul L., 1700 Electric Bldg., Fort Worth, Tex. . . . . '19
Argabrite, William Graeme, 517 E. Harrison Ave., Guthrie, Okla. . . . . '28
||Arick, Millard B., Box 938, McCamey, Tex. . . . . '27
||Armor, Mildred V., 3711 Classen Blvd., Oklahoma City, Okla. . . . . '30
Armstrong, Harold K., Room 838, 727 W. Seventh St., Los Angeles, Calif. . . . . '27
Armstrong, J. M., Prairie Oil & Gas Co., Eastland, Tex. . . . . '18
Arnett, Clarence L., 301 S. Eighth St., Ponca City, Okla. . . . . '27
Arnold, Emmett L., 538 Mayo Bldg., Tulsa, Okla. . . . . '27
Arnold, Harry H., Jr., 749 E. Liberty St., Clarion, Pa. . . . . '27
||Arnold, Henry C., Box 97, Earlsboro, Okla. . . . . '30
Arnold, Ralph, 1201 E. California St., Pasadena, Calif. . . . . '18
Aronson, Sam M., 701 Magnolia Bldg., Dallas, Tex. . . . . '24
Artman, George W., Box 1651, Amarillo, Tex. . . . . '25
||Atchison, J. Wilbur, Pure Oil Co., Box 1007, Fort Worth, Tex. . . . . '31
Athy, Lawrence F., Geophysical Division, Continental Oil Co., Ponca City, Okla. . '26
Atkinson, William H., 701 Continental Bldg., Oklahoma City, Okla. . . . . '22
Atwill, E. R., Box 552, Bakersfield, Calif. . . . . '31
Aurand, Harry A., 1350 Bellaire St., Denver, Colo. . . . . '26
Aurin, Fritz L., Southland Royalty Co., Ponca City, Okla. . . . . '17
Autry, Vernon E., Humble Oil & Refining Co., Wichita Falls, Tex. . . . . '26
Avery, C. Dwight, U. S. Geological Survey, 3240 Interior Bldg., Washington, D. C. '28
||Ayers, Floyd M., Sabetha, Kan. . . . . '30

Bace, A. C., 803 San Angelo Natl. Bank Bldg., San Angelo, Tex. . . . . '24
||Bacon, Charles S., Jr., Geology Dept., Riverside Junior College, Riverside, Calif. '29
Baden, M. W., Box 520, 201-202 Baden Bldg., Winfield, Kan. . . . . '21
Bagg, Rufus M., 16 Brokaw Place, Appleton, Wis. . . . . '27
||Bailey, Joe, 1201 E. Eleventh St., Winfield, Kan. . . . . '30
Bailey, Thomas L., Box 713, Ventura, Calif. . . . . '24
Bain, H. Foster, 29 W. Thirty-Ninth St., New York, N. Y. . . . . '26
Baird, Chester A., Apartado 234, Venezuela Gulf Oil Co., Maracaibo, Venezuela, S. A. . . . . '21
Baker, Arthur A., U. S. Geological Survey, Washington, D. C. . . . . '30
Baker, Charles L., 529 Commercial Bank Bldg., Houston, Tex. . . . . '19

*Honorary member. †Life member. ||Associate. Members are not marked. The year refers to date of election to the Association, not necessarily to class of membership.

||Baker, Lara H., Box 561, Longview, Tex. .... '29
Baker, Norval E., Room 1567, 26 Broadway, New York, N. Y. .... '27
Baker, Raymond F., The Texas Co., Geol. Dept., 135 E. Forty-Second St., New York, N. Y. .... '17
Baker, William A., Jr., Cia. de Petr. Mercedes, S. A., Apartado 269, Monterrey, N. L., Mexico .... '24
||Bakke, W. E., Shell Petr. Corp., Box 1555, Oklahoma City, Okla. .... '28
Baldwin, E. B., 2122 Alamo Natl. Bank Bldg., San Antonio, Tex. .... '29
Baldwin, Harry L., Jr., 2236 W. Twenty-Second St., Oklahoma City, Okla. .... '22
Bale, Hubert E., 1130 W. Forty-First St., Oklahoma City, Okla. .... '24
Ball, Max W., 715 First Natl. Bank Bldg., Denver, Colo. .... '19
Ball, Sydney H., 26 Beaver St., New York, N. Y. .... '19
||Ballard, Andrew L., 1518 Alamo Natl. Bldg., San Antonio, Tex. .... '21
Ballard, James L., Box 590, Tyler, Tex. .... '25
||Ballard, William Norval, 1201 Hales Bldg., Oklahoma City, Okla. .... '29
||Banks, Overton B., 2250 Neches St., Beaumont, Tex. .... '30
Banks, Thomas R., 1003 Fourth St., Corpus Christi, Tex. .... '27
||Barbat, William F., Standard Oil Co., Taft, Calif. .... '28
Bard, Richards J., Wayne, Pa. .... '28
||Barling, Robert, 606 Milam Bldg., San Antonio .... '27
Barlow, Victor, 121 N. Hill St., Los Angeles, Calif. .... '27
Barnes, Roy M., Continental Oil Co., 417 S. Hill St., Los Angeles, Calif. .... '24
Barnett, D. G., 1303 Rosario, Laredo, Tex. .... '25
||Barnett, J. A., Southern Crude Oil Purchasing Co., 1704 Milam Bldg., San Antonio, Tex. .... '28
||Barney, Arthur Y., Piney Oil & Gas Co., 1139 Milam Bldg., San Antonio, Tex. .... '30
||Barnhart, Carl F., Box 1144, Wichita, Kan. .... '29
Barnwell, George F., Ned. Kol. Petr. Mij., Weltevreden, Java, D. E. I. .... '28
||Barragy, Edward J., Box 1557, Oklahoma City, Okla. .... '31
||Barrett, Albert F., Parco, Wyo. .... '30
||Barrett, Claude L., Twin State Oil Co., Box 1501, Tulsa, Okla. .... '28
Barrett, Morris K., Box 181-A, Wheatridge, Colo. .... '27
Barrett, W. Gladstone, Geological Dept., Anaconda Copper Co., Butte, Mont. .... '22
Barrow, Leonidas T., 1216 Hawthorne St., Houston, Tex. .... '22
||Bartell, Laurence D., Box 313, Pauls Valley, Okla. .... '27
Barth, William A., Imperial Oil & Gas Products Co., Owensboro, Ky. .... '23
Bartle, Glenn G., Kansas City Junior College, Kansas City, Mo. .... '27
||Bartle, Ronald L., 2112 N. Villa, Oklahoma City, Okla. .... '28
||Bartlett, C. Lothrop, Sun Oil Co., Beaumont, Tex. .... '28
Bartlett, Fred W., Shell Petroleum Corp., Box 1672, Dallas, Tex. .... '24
Barton, Donald C., Petroleum Bldg., Houston, Tex. .... '20
Barton, Louis A., Box 433, Shreveport, La. .... '20
Bartosh, Edmund J., 395 S. Santa Cruz St., Ventura, Calif. .... '28
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Cole, W. Storrs, Sun Oil Co., Box 2880, Dallas, Tex. .... '27
Coleman, Bond, Mound City, Kan. .... '25
Coleman, Tom L., Box 1074, Wichita Falls, Tex. .... '24
Collingwood, D. M., Box 2880, Sun Oil Co., Dallas, Tex. .... '21
Collins, C. Philip, 705 S. Second St., McAlester, Okla. .... '25
Collins, Melvin J., Big Lake Oil Co., Texon, Tex. .... '24
||Collins, W. H., 1846 E. Seventeenth St., Tulsa, Okla. .... '22
Collom, Roy E., 715 Kenneth Road, Glendale, Calif. .... '19
||Colman, I. C., Apartado 234, Maracaibo, Venezuela, S. A. .... '30
||Colt, Frances Neele, Manila, P. I. .... '29
Colton, Earl G., Okmulgee, Okla. .... '29
Comstock, William S., 512 Union Oil Bldg., Los Angeles, Calif. .... '28
Condit, D. Dale, Western Gulf Oil Co., 1221 Subway Terminal Bldg., Los Angeles, Calif. .... '21
Conkling, R. A., 804 Colcord Bldg., Oklahoma City, Okla. .... '17
Conkling, Russell C., Box 620, San Angelo, Tex. .... '22
Conkling, William H., 1524 Shafter St., San Angelo, Tex. .... '22

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||Conners, Thomas P., Box 1731, Shreveport, La. .... '30
Connock, R. F., Caribbean Petroleum Co., Maracaibo, Venezuela, S. A. .... '30
||Conrad, Charles S., 918 Chrysler Bldg., New York, N. Y. .... '29
Cook, Carroll E., 506 West Twenty-Second St., Austin, Tex. .... '22
Cook, Harold J., Agate, Nebr. .... '20
||Cook, Lorry A., Southern Crude Oil Purchasing Co., Box 1735, Shreveport, La. . '29
||Cooper, Chalmer L., Oklahoma Geological Survey, Norman, Okla. .... '26
Cooper, Herschel H., 1442 Milam Bldg., San Antonio, Tex. .... '25
||Copass, Jack M., Box 707, Chickasha, Okla. .... '27
Copeland, Richard G., 501 W. Front St., Tyler, Tex. .... '27
Copelin, Leonard S., 310 Union Oil Bldg., Los Angeles, Calif. .... '30
Corbett, Clifton S., Gulf Oil Corp., 21 State St., New York, N. Y. .... '19
Corby, Grant W., Box 514, Arcadia, Los Angeles Co., Calif. .... '26
||Cordry, C. D., Box 737, Fort Worth, Tex. .... '29
||Cornell, Lee H., 413 First Natl. Bank Bldg., Wichita, Kan. .... '27
||Corning, Leavitt, Jr., 6202 Howe St., Pittsburgh, Pa. .... '30
||Cortes, Henry C., Vacuum Oil Co., Box 1426, Houston, Tex. .... '30
||Coryn, F. R., Box 983, Fort Worth, Tex. .... '30
Coryell, Horace N., Columbia University, New York, N. Y. .... '26
Coryell, Lewis S., 337 W. Fifth St., Bristow, Okla. .... '20
Cotner, Victor, Box 1141, Amarillo, Tex. .... '27
Cottingham, Kenneth, Columbia Eng. & Management Corp., 99 North Front St., Columbus, Ohio ... '28
Cottingham, Virgil E., Box 474, San Angelo, Tex. .... '21
Cotulla, Louis E., Box 235, Albany, Tex. .... '26
Cotulla, Reuben E., 2209½ Jones St., Wichita Falls, Tex. .... '26
||Coulson, Harry S., 513 N. W. Fourth Ave., Mineral Wells, Tex. .... '28
||Courtier, William H., Kinsley, Kan. .... '28
Cox, Benjamin Burton, c/o C. Stuart Morgan, Room 417, 26 Broadway, New York, N. Y. ... '26
||Cox, Thomas S., Box 489, Beeville, Tex. .... '28
||Craft, Benjamin C., Louisiana State University, Baton Rouge, La. .... '30
Craig, Eric K., 1625 Opechee Way, Glendale, Calif. .... '28
Cram, Ira H., 1408 S. Indianapolis, Tulsa, Okla. .... '26
Cramer, Louis W., Stockton Hotel, Fort Stockton, Tex. .... '27
Crandall, Hector, Pres., Anadarko Western Oil Co., 2002 Philtower Bldg., Tulsa, Okla. ... '24
Crandall, Kenneth H., The California Co., Marvin Bldg., Dallas, Tex. .... '23
Crandall, Richard R., 945 Schumacher Drive, Los Angeles, Calif. .... '24
Crandall, Roderic, 17 Battery Place, New York, N. Y. .... '24
Cranson, Lorin A., Room 309 Central Bldg., Santa Barbara, Calif. .... '29
Crawford, David J., 3251 Culver St., Dallas, Tex. .... '27
Crebbs, Chester M., Apartado 234, Maracaibo, Venezuela, S. A. .... '22
Crider, Albert F., 821 Ontario St., Shreveport, La. .... '22
||Crider, Hugh D., 431 Lyman Bldg., Muskegon, Mich. .... '28
||Crist, Raymond E., 3533 Vista Ave., Cincinnati, Ohio .... '30
Croneis, Carey, Walker Museum, University of Chicago, Chicago, Ill. .... '29
Crook, Theo H., 1675 Euclid Ave., Berkeley, Calif. .... '24
Crooks, Harold F., Romano-Americana, 126 Calea Victoriei, Bucharest, Roumania '23
||Crosby, Arthur S., 923¾ N. Serrano Ave., Hollywood, Calif. .... '28
||Crotty, James W., 502 Rust Bldg., San Angelo, Tex. .... '27
Crouse, George T., Shell Petroleum Corp., Box 1865, Houston, Tex. .... '27
Crum, Harry E., Skelly Oil Co., Amarillo, Tex. .... '23
Cruse, John S., Jr., Pure Oil Co., 2213 Esperson Bldg., Houston, Tex. .... '26
Cullen, John, Continental Oil Co., Box 1267, Ponca City, Okla. .... '19
Cullen, Ronald J., Twin State Oil Co., Box 1501, Tulsa, Okla. .... '23

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Culver, Harold E., State College of Washington, Pullman, Wash. '24
Cumming, Alfred, Ketchum Hotel, Tulsa, Okla. '24
Cunningham, Carleton J., 1410 Lynwood Ave., San Antonio, Tex. '29
Cunningham, George M., 2610 Nineteenth St., Bakersfield, Calif. '24
||Curry, William H., Jr., Shell Petr. Corp., City Natl. Bank Bldg., San Antonio, Tex. '28
Curtice, A. Arthur, 435 A. G. Bartlett Bldg., 215 W. Seventh St., Los Angeles, Calif. '24
||Cushing, John W., Sistersville, W. Va. '30
Cushman, Joseph A., 76 Brook Road, Sharon, Mass. '24
Cutler, Willard W., Jr., 902 Broadway Arcade Bldg., Los Angeles, Calif. '17
Cuyler, Robert H., 1216 W. Twenty-Second St., Austin, Tex. '29

Dake, Charles L., 1106 Main St., Rolla, Mo. '27
Dakin, Francis W., 1134 Hinman Ave., Evanston, Ill. '23
||Dallmus, Karl F., Cia. de Petr. Mercedes, S. A., Apartado 269, Monterrey, N. L., Mexico '28
Dally, Claude F., 4120 Mattison, Fort Worth, Tex. '20
Damon, Gordon, Box 1609, University Station, Austin, Tex. '29
Dana, Drexler, La Cumbre Road, Santa Barbara, Calif. '27
||Dana, Edward B., Box 143, Belpre, Ohio '26
||Dana, P. L., Box 2044, Geol. Dept., Tulsa, Okla. '30
||Daniel, Orion A., 503 Perkins-Snyder Bldg., Wichita Falls, Tex. '30
Daniels, Harold G., 518 W. Woodlawn, San Antonio, Tex. '21
Daniels, James I., Continental Oil Co., Ponca City, Okla. '24
Dannenberg, R. M., Comar Oil Co., Marland, Tex. '25
Dannettell, Merle Q., 2340 Cherry St., Denver, Colo. '24
Danvers, Don, 1715 Milam Bldg., San Antonio, Tex. '26
Darke, Roy E., 2004 Truxton, Bakersfield, Calif. '27
Darnell, James L., 420 Lexington Ave., Room 1951, New York, N. Y. '22
||Darnell, James L., Jr., Room 1415, 111 Broadway, New York, N. Y. '28
||Daszynski, Stephen W., Iraq Petr. Co., Geol. Dept., Kirkuk, Iraq '28
||Daubert, Charles A., 1914 Speedway, Wichita Falls, Tex. '25
Davies, Fred A., Box 2410, The California Co., Denver, Colo. '20
Davies, Herman F., Box 2410, Denver, Colo. '27
||Davies, Nathan C., Box 663, Cushing, Okla. '29
Davies, Stanley James, 1128 Prospect Ave., Calgary, Alta., Canada '31
Davila, Salvador Ortiz, Huasteca Petroleum Co., Tampico, Mexico '29
||Davis, Charles A., 505 W. Monroe St., Phoenix, Ariz. '27
Davis, Donald M., The Pure Oil Co., Houston, Tex. '26
Davis, Elmer Fred, 417 E. Randolph St., Glendale, Calif. '21
||Davis, Fenelon F., The California Co., Midland, Tex. '29
||Davis, Field M., Southern Crude Oil Purchasing Co., Wink, Tex. '31
Davis, Morgan J., Nederlandsche Kol. Petr. Mij., Batavia, Java, D. E. I. '26
Davis, Ralph E., 1710 Union Bank Bldg., Pittsburgh, Pa. '19
Davis, Robert J., Shell Petroleum Corp., Drawer 8, St. Louis, Mo. '21
Davis, Thornton, Simms Oil Co., 2302 Alamo Natl. Bank Bldg., San Antonio, Tex. '25
||Dawson, Edwin A., Box 491, Wichita, Kan. '30
Dawson, Joseph M., Box 564, San Antonio, Tex. '23
Dawson, William A., Shell Petroleum Corp., Box 236, Woodward, Okla. '26
Day, Clarence O., Phillips Petroleum Co., 708 Slattery Bldg., Shreveport, La. '20
||Day, James R., 1718 Milam Bldg., San Antonio, Tex. '30
Day, Willard L., 1607 Topeka Blvd., Topeka, Kan. '26
Dean, Calvin J., 319 Haberfelde Bldg., Bakersfield, Calif. '30
Dean, D. P., 1816 W. T. Waggoner Bldg., Fort Worth, Tex. '19
Dean, P. C., 1816 W. T. Waggoner Bldg., Fort Worth, Tex. '19
De Chicchis, Romaldo, Southern Crude Oil Purchasing Co., Midland, Tex. '29

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Decius, L. Courtney, Associated Oil Co., 79 New Montgomery St., San Francisco, Calif. '19
*Decker, Charles E., 508 Chautauqua Ave., Norman, Okla. '17
||Decker, LaVerne, 1521 Harvard St., Houston, Tex. '27
de Cizancourt, Henry, Cie Fr. des Petroles, 63 Ave. Victor Emmanuel III, Paris, France '29
de Cousser, Kurt H., Prairie Oil & Gas Co., Box 263, Tulsa, Okla. '27
DeFord, Ronald K., Box 681, Roswell, N. Mexico '25
DeGolyer, E., 65 Broadway, New York, N. Y. '17
||Delehanty, R. V., 530 N. Broadview, Wichita, Kan. '31
||Delo, David M., Dept. of Geology, Northwestern University, Evanston, Ill. '29
de Loys, Francis, 63 St. James' St., London, S. W. 1, England '21
Denison, A. Rodger, Amerada Petroleum Corp., Box 1348, Fort Worth, Tex. '21
Denman, C. E., 209 S. Ninth St., Enid, Okla. '26
||Denning, Wayne H., Box 284, Golden, Colo. '28
||Deputy, P. R., 357 Haberfelde Bldg., Bakersfield, Calif. '30
Deussen, Alexander, 1606 Post Dispatch Bldg., Houston, Tex. '17
De Wolf, Frank W., 3502 Audubon Pl., Houston, Tex. '20
Dicken, Russell H., 105 N. E. Eighth St., Oklahoma City, Okla. '28
Dickerson, Roy E., Apartado 300, Caibarien, Cuba '25
||Dickson, Hugh, Box 299, Ardmore, Okla. '28
Dillé, Glenn Scott, Box 337, Fairview, Okla. '28
Disney, Orville A., General Delivery, Sedan, Kan. '20
Dissinger, Earl, 1915 E. Alabama Ave., Houston, Tex. '20
Dixon, A. Faison, 37 Clifford Ave., Pelhamwood, N. Y. '19
Doane, George H., Wacific Western Oil Co., 1709 W. Eighth St., Los Angeles, Calif. '26
Dobbin, Carroll E., Room 212 Custom House Bldg., Denver, Colo. '22
Dobie, Walter L., Box 773, El Dorado, Ark. '26
Dodge, John F., Division of Petroleum Engineering, University of Southern California, Los Angeles, Calif. '24
Dodson, Floyd C., 208 S. Park St., San Angelo, Tex. '23
Doering, John, Penn Oil Co., 303 First Natl. Bank Bldg., Dallas, Tex. '30
Dolman, Phil B., 4740 Balboa St., San Francisco, Calif. '21
||Dolphin, Adrian J., Box 154, Owensboro, Ky. '20
Donahue, Frank, 402 S. Fourth St., Ponca City, Okla. '25
||Donnelly, Alden Stuart, Box 776, Midland, Tex. '30
Donnelly, L. G., 302 Coronado Road, Santa Fé, N. Mexico '17
Donoghue, David, 1116 Fort Worth Natl. Bank Bldg., Fort Worth, Tex. '18
Donovan, Percy W., 1701 Foshay Tower, Minneapolis, Minn. '19
Dorchester, Charles M., Gulf Refining Co., Box 1731, Shreveport, La. '19
Dorr, James B., Huasteca Petroleum Co., Apartado 94, Tampico, Mexico '25
Dorrance, James R., 2720 W. Eighteenth St., Bakersfield, Calif. '26
Dorsey, Geo. Edwin, Box 904, Dallas, Tex. '24
Dott, Robert H., Sunray Oil Corp., 740 Philcade Bldg., Tulsa, Okla. '19
Douglas, James M., Union Natl. Petroleum Co., Apartado 398, Maracaibo, Venezuela, S. A. '23
Douglas, John G., Lago Petr. Corp., Apartado 172, Maracaibo, Venezuela, S. A. '27
||Douglas, L. A., 717 Perrine Bldg., Oklahoma City, Okla. '30
||Douglass, O. Hubert, Jr., 2832 W. Seventeenth St., Oklahoma City, Okla. '27
Dovre, Adolph, 632 Milam Bldg., San Antonio, Tex. '22
Downing, Roswell B., 607 Union Natl. Bank Bldg., Wichita, Kan. '30
Doyle, John J., Humble Oil & Refg. Co., Box 270, Beaumont, Tex. '24
||Dragusanu, J. B., Box 137, Oakland St., Pittsburgh, Pa. '29
Drake, Cecil, Apartado 150, Tampico, Mexico '29
Dreher, Otto, Carel van Bylandtlaan 30, The Hague, Holland '21
Dresser, Myron A., Box 171, Elk City, Okla. '19

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Driver, Herschel L., 630 Palm Drive, Glendale, Calif. .... '25
Duce, James Terry, c/o A. C. Hunter, The Texas Co., 135 E. Forty-Second St., New York, N. Y. .... '20
||Duce, Robert S., 1153 Lincoln St., Boulder, Colo. .... '30
Dufour, Jan, Caribbean Petroleum Corp., Maracaibo, Venezuela, S. A. .... '30
Dugan, Ira E., 301 S. Lake St., Ponca City, Okla. .... '24
Dunlevy, Robert B., 302 College St., Winfield, Kan. .... '21
Dunn, George V., 2035 E. Fourteenth St., Tulsa, Okla. .... '22
Durkee, Robert R., Dixie Oil Co., 901 Frost Natl. Bank Bldg., San Antonio, Tex. '28
Durward, Robert Harland, Box 106, Texon, Tex. .... '26
Duston, Arthur W., 415 Philtower Bldg., Tulsa, Okla. .... '21
Dyer, William S., Dept. of Mines, East Block, Parliament Bldgs., Toronto, Ont., Canada .... '28

Eagles, Homer M., Room 1080, 26 Broadway, New York, N. Y. .... '22
Earl, Will F., Mid-Kansas Oil & Gas Co., Tulsa, Okla. .... '25
Eastman, Walter F., 9 Locust Ave., Danbury, Conn. .... '26
Easton, H. D., Suite 309, Slattery Bldg., Shreveport, La. .... '17
Eaton, Joseph E., 628 Petroleum Securities Bldg., Los Angeles, Calif. .... '25
Ebmeyer, Gerard E., 1327 N. Second St., Arkansas City, Kan. .... '23
Eby, J. Brian, Box 1865, Houston, Tex. .... '25
Eckert, Frank E., Hanley and Bird, Bradford, Pa. .... '21
Eckes, Charles R., 1014 S. Boston, Tulsa, Okla. .... '17
Eckhardt, E. A., 1520 Shady Ave., Pittsburgh, Pa. .... '30
Edson, Dwight J., Box 101, San Angelo, Tex. .... '22
Edson, Fanny C., Shell Petroleum Corp., Box 1162, Tulsa, Okla. .... '22
Edson, Frank A., 503 Alworth Bldg., Duluth, Minn. .... '19
Edwards, Everett C., 1227 Viscaino St., Glendale, Calif. .... '23
||Edwards, Hall, 740 Philcade Bldg., Tulsa, Okla. .... '28
Edwards, Merwin G., 428 Grand Ave., S. Pasadena, Calif. .... '25
Egan, John A., 502 Thompson Bldg., Tulsa, Okla. .... '23
||Eichelberger, John R., 754 S. Grove St., Wichita, Kan. .... '30
Eichelberger, Orion H., 606 Pujo St., Lake Charles, La. .... '23
Eirich, Constance G., Box 2044, Tulsa, Okla. .... '21
||Ekholm, Victor E., 516 W. Third St., Coleman, Tex. .... '28
Elin, Nicholas D., State Oil Trust, "Grozneft" Grozny, U. S. S. R. .... '31
Elledge, Emmett R., Phillips Petroleum Co., Breckenridge, Tex. .... '25
||Ellicott, F. M., Apt. 3, 824 Blaylock Drive, Dallas, Tex. .... '30
Elliott, George R., 2 Immigration Bldg., Calgary, Alta., Canada .... '26
Elliott, John E., 850 Subway Terminal Bldg., 417 S. Hill St., Los Angeles, Calif. .. '19
Ellis, George L., Box 1256, Charleston, W. Va. .... '24
Ellison, Charles W., Blackwell Oil & Gas Co., Brownwood, Tex. .... '30
Ellison, Kenneth A., H. F. Wilcox Oil & Gas Co., Tulsa, Okla. .... '28
Ellisor, Alva C., 903 Humble Bldg., Houston, Tex. .... '21
Elson, William H., 306 Beacon Life Bldg., Tulsa, Okla. .... '27
Ely, Fred B., 123 E. Forty-Second St., New York, N. Y. .... '20
Emch, John W., Box 452, San Angelo, Tex. .... '25
||Emendorfer, Earl, 1377 Monroe St., Hammond, Ind. .... '27
Emery, Wilson B., 1041 S. Center St., Casper, Wyo. .... '23
Emmons, William H., University of Minnesota, Minneapolis, Minn. .... '19
Emrick, D. G., Drawer C, Houston, Tex. .... '28
Emrick, E. B., Box 496, Conrad, Mont. .... '22
Engel, Rene L. H., Dept. of Geology, Calif. Institute of Technology, Pasadena, Calif. .... '25
Engleman, Rolf, Apartado 58, Caracas, Venezuela, S. A. .... '25
English, Leon E., 806 Euclid Ave., Lawton, Okla. .... '18
English, Walter A., 1100 City Natl. Bank Bldg., Los Angeles, Calif. .... '19

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Erdmann, Charles E., 212 Custom House Bldg., Denver, Colo. .... '30
Erni, Arthur, Landhaus Kully, Trimbach, Kt. Solothurn, Switzerland .... '21
||Erwin, Andrew V., 818 Kennedy Bldg., Tulsa, Okla. .... '21
Escher, Frank, Min. Petr. Institute der E. T. H., Sonneggstrasse, Zurich, Switzerland .... '27
Esgen, W. K., Humble Oil & Refg. Co., Cisco, Tex. .... '29
||Eskrigge, Tatham R., 16th Floor Frick Bldg. Annex, Pittsburgh, Pa. .... '30
Estabrook, Edward L., Pan-American Petr. & Trans. Co., 122 E. Forty-Second St., New York, N. Y. .... '20
Estergren, E. F., 1011 Sixth Ave., Fort Worth, Tex. .... '29
||Evans, Eugene P., Box 2022, Tulsa, Okla. .... '30
Evans, Frank G., Jr., 209 Luckett Ave., Longview, Tex. .... '28
||Evans, Louis H., 1100 Citizens Natl. Bank Bldg., Los Angeles, Calif. .... '30
Evans, Noel, Box 169, Guthrie, Okla. .... '20
Eyl, W. C., 1851 Limestone St., Lexington, Ky. .... '24
Eyoub, Djevad, 302 Furr Drive, San Antonio, Tex. .... '26
Eyssell, Alfred R., 813 Alamo Natl. Bank Bldg., San Antonio, Tex. .... '25

Fagin, Verne A., 538 E. Cincinnati, San Antonio, Tex. .... '27
||Fahmy, E. H., No. 5, Bateniah St., El Azhar, Cairo, Egypt .... '26
Farish, Linn M., Albert Gas & Fuel Co., Pincher Creek, Alta., Canada .... '28
||Farrell, Agnes M., 1673 Columbia Road, N. W., Washington, D. C. .... '26
Fash, Ralph H., Box 1008, Fort Worth, Tex. .... '27
Fath, A. E., Chrisman, Ill. .... '17
||Faulkner, Hastings M., Box 673, Meridian, Miss. .... '30
||Faust, Josef, 1215 N. Hudson, Oklahoma City, Okla. .... '31
||Feagin, Barney, Jr., 1122 E. Twentieth St., Tulsa, Okla. .... '30
Fenn, Ivan J., Box 1508, Wichita Falls, Tex. .... '29
Fergus, Preston, 400 Forsythe, Monroe, La. .... '27
||Ferguson, Glenn C., 604 Beaux Arts Bldg., 1708 W. Eighth St., Los Angeles, Calif. .... '30
Ferguson, John L., Box 2022, Tulsa, Okla. .... '20
Ferguson, Kenneth S., 2060 Dahlia St., Denver, Colo. .... '27
Ferguson, R. N., 547 Subway Terminal Bldg., 417 S. Hill St., Los Angeles, Calif. .. '19
||Ferguson, William Boyd, Box 553, Brenham, Tex. .... '29
||Ferrero, Clarence, Shell Petr. Corp., Sterling Bldg., Houston, Tex. .... '28
Fettke, Charles R., 1118 Wightman St., Pittsburgh, Pa. .... '20
||Field, R. H., H. L. Doherty & Co., 60 Wall St., New York, N. Y. .... '30
||Field, Walter S., 421 Ellis Singleton Bldg., Wichita, Kan. .... '28
||Fields, Harry B., The Texas Co., Box 912, Tulsa, Okla. .... '28
Finch, Elmer H., Atlantic Oil Producing Co., 310 Milam Bldg., San Antonio, Tex. '22
Finch, John Wellington, Idaho Bureau of Mines and Geology, University of Idaho, Moscow, Idaho .... '24
||Fipps, E. L., 3549 Granada, Dallas, Tex. .... '26
Fischer, Otto, Box 1375, Charleston, W. Va. .... '17
Fisher, D. J., Rosenwald Hall, University of Chicago, Chicago, Ill. .... '27
||Fitts, John, 910 E. Seventeenth St., Ada, Okla. .... '27
FitzGerald, James, Jr., Skelly Oil Co., 434 Commercial Exchange Bldg., Oklahoma City, Okla. .... '25
||Fitzgerald, Paul E., 402 Second Natl. Bank Bldg., Saginaw, Mich. .... '30
||Fitzgerald, Thomas J., 1111 Oxford St., Berkeley, Calif. .... '29
||Flagler, C. W., Apartado 234, Maracaibo, Venezuela, S. A. .... '30
Fletcher, Corbin D., Box 673, Meridian, Miss. .... '27
Floyd, Florin W., Box 164, Duncan, Okla. .... '23
Fohs, F. Julius, 51 E. Forty-Second St., New York, N. Y. .... '17
Foley, Lyndon L., Box 2064, Tulsa, Okla. .... '22

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Folger, Anthony, Gypsy Oil Co., Box 1144, Wichita, Kan. '22
||Fonville, Herman A., 1200 Ohio Ave., Wichita Falls, Tex. '27
||Foraker, William S., 40 Southard Bldg., Zanesville, Ohio '26
Ford, Carl S., Box 768, Enid, Okla. '18
Forgeron, H. S., Box 1282, Midland, Tex. '28
Forgotson, James M., 203 S. Dartmouth St., Albuquerque, N. Mexico '29
||Forman, Frank, Geological Survey Office, Perth, Western Australia '30
Forrester, George A., 251 S. Rutan St., Wichita, Kan. '20
Fortier, Leo R., Box 1210, Wichita, Kan. '25
Fortine, Dwight H., Caribbean Petroleum Co., Maracaibo, Venezuela, S. A. '30
Foster, Alden W., 1710 Union Bank Bldg., Pittsburgh, Pa. '20
Foster, Fred E., 940 Roosevelt Bldg., Los Angeles, Calif. '28
Foster, F. K., Box 12, San Angelo, Tex. '21
Foster, Walter L., 1127 S. Evanston, Tulsa, Okla. '21
Foster, William H., 1401 Exchange Natl. Bank Bldg., Tulsa, Okla. '19
Fowle, L. V. A., 107 The Mall, Swindon, England '31
Fowler, Charles W., Jr., 334 Milam Bldg., San Antonio, Tex. '26
Fowler, George M., 314 Joplin Natl. Bank Bldg., Joplin, Mo. '23
||Fox, Ira William, 701 Oakland Ave., Greensburg, Pa. '27
||Fox, James P., 225 Bush St., Standard Oil Co., San Francisco, Calif. '29
Fox, Leo S., General Petroleum Corp., 1003 Higgins Bldg., Los Angeles, Calif. '27
||Francis, George A., Gulf Production Co., Drawer C, Houston, Tex. '26
Franklin, Louis, 547 Harvey-Snider Bldg., Wichita Falls, Tex. '20
||Franks, Robert M., 516 Milam Bldg., San Antonio, Tex. '30
Frazier, Gaylord G., Box 240, Denver, Colo. '28
Freedman, L. H., 1402 Sinclair Bldg., Fort Worth, Tex. '22
Frei, Frederick, Shell Petroleum Corp., Box 1672, Dallas, Tex. '25
||Freie, A. J., Trinidad Oil Fields Operating Co., Box 18, Trinidad, San Fernando, B. W. I. '28
Frey, Alfred P., Cia. "El Aguila," Apartado 86, Puerto Mexico, Ver., Mexico '24
Fritts, Harold M., 1729 Albert St., Alexandria, La. '26
||Fritz, Earl R., Apartado 234, Maracaibo, Venezuela, S. A. '30
Froyd, Erwin A., Midwest, Wyo. '22
||Fuellhart, Donald E., 405 Fairfax Bldg., Kansas City, Mo. '29
||Fulton, Loris J., Pure Oil Co., Geol. Dept., Tulsa, Okla. '29
||Funk, Fred J., Box 1079, Casper, Wyo. '28
Funk, Marion H., 922 Clifton Court, Fort Smith, Ark. '24
Fuqua, H. B., Box 737, Fort Worth, Tex. '20
Fyfe, Douglas, 215 W. Seventh St., Los Angeles, Calif. '20

Gaddess, Jack, North Pennsylvania Gas Co., Port Allegany, Pa. '25
Gahring, William R., Box 520, Shawnee, Okla. '25
Galbraith, T. J., 430 Elmhurst, San Antonio, Tex. '20
||Gale, Hoyt Rodney, 1775 Hill Drive, Los Angeles, Calif. '29
Gale, Hoyt S., 1775 Hill Drive, Los Angeles, Calif. '23
||Gallagher, William G., Union Oil Co. of Nevada, Mims Bldg., Abilene, Tex. '24
||Galley, John E., Shell Petr. Corp., Box 1555, Oklahoma City, Okla. '29
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AT HOME AND ABROAD

CURRENT NEWS AND PERSONAL ITEMS OF THE PROFESSION

Employment

The Association maintains an employment service at headquarters under the supervision of the business manager.

This service is available to members who desire new positions and to companies and others who desire Association members as employees. All requests and information are handled confidentially and gratuitously.

To make this service of maximum value it is essential that members coöperate fully with headquarters especially concerning positions available to active and associate members.

A. L. Solliday is chief landman of the land department of the Stanolind Oil and Gas Company, Tulsa, Oklahoma.

W. E. Wrather, of Dallas, Texas, will give a series of lectures on the petroleum industry at Northwestern University during March.

David White, of the U. S. Geological Survey, has delivered a series of lectures at Yale University on the origin and nature of coal.

W. Taylor Thom has been touring the western part of the United States in the interest of Prinçeton University and has given talks at meetings of several local geological societies.

J. M. McMillan, Jr., has resigned his position as subsurface geologist with the Skelly Oil Company in Kansas and is now district geologist for the Cities Service Companies. His address is 133 West Gray Street, Elmira, New York.

C. L. Baker, 529 Commercial Bank Building, Houston, Texas, addressed the Houston Geological Society on January 13 on the subject of "Glacial Deposits of the Upper Haymond in the Marathon Area."

W. F. Cummins, of El Paso, Texas, retired geologist of the Southern Pacific Company and its subsidiaries, the Rio Bravo Oil Company and the East Coast Oil Company, died on January 8, 1931, at the age of 90 years.

Floyd Miller, for the last 3 years head of the land and geological department of the Reiter-Foster Oil Company, resigned January 1, to engage in general consulting work. He will specialize in the regional geology of the Rocky Mountain and Mid-Continent areas. His home address is 1518 South Utica, Tulsa.

W. Storrs Cole, of the Sun Oil Company, Dallas, and Gerald M. Ponton, Florida State Geological Survey, Tallahassee, Florida, are the au-

thors of the Florida Geological Survey's new *Bulletin 5*, "The Foraminifera of the Marianna Limestone of Florida." The first part of the bulletin contains a paper by WILLIAM K. GREGORY on "A Fossil Teleost Fish of the Snapper Family (Lutianidae) from the Lower Oligocene of Florida."

Many members and subscribers are taking advantage of the low price of the bound volume of the *Bulletin* ($4.00 in addition to regular dues or subscription; at this price, only one copy to a member or subscriber) to secure this extra set for their reference libraries so that they may use their current paper-cover copies to tear apart and reassemble in subject groups to meet their particular needs. Each new article in the *Bulletin* commences on a new right-hand page, so that it can be removed without disturbing the preceding or following article.

The Committee on Sedimentation of the National Research Council, at its meeting in Toronto, Canada, on December 29, 1930, allocated to R. A. STEINMAYER, of The Tulane University of Louisiana, New Orleans, a sum of money to assist in the continuation of his study of the bottom sediments of Lake Ponchartrain.

The Bureau of Economic Geology of the University of Texas, Austin, has recently published two reports, "Contributions to Geology, 1930" (*Bulletin 3001*), and the "United States Geological Survey Professional Paper 126" (as a reprint) from the *Paul Franklin Morse Memorial Publication Fund*.

FOREST R. REES, Box 1594, Tulsa, Oklahoma, is pre-organization manager of the Rees Record Map System, specializing on loose-leaf section and township plats for systematic recording of well data.

W. W. KEELER has returned to Tulsa as geologist for the Minnehoma Oil and Gas Company. For several months Mr. Keeler has been acting as geologist for the Getty Petroleum Corporation at Fort Worth, Texas, but this office has now been closed.

The Los Angeles Museum has a collection of bones recovered from the Brea deposit in the old Salt Lake oil field. From a count of leg bones of birds they find that they have partial skeletons of 4,189 individual birds.

A. A. LANGWORTHY is engaged in field geological investigations for The Pure Oil Company in California.

R. B. HARKNESS, of the Ontario Department of Mines, Toronto, Canada, gives a very interesting discussion of the history of the use of the divining rod since the reign of Queen Elizabeth, in the *37th Annual Report of the Ontario Department of Mines*, Part V (1928), pp. 44-50.

W. A. BAKER, JR., is chief geologist, G. F. KAUFMANN is geophysical chief, and ELI T. MONSOUR is paleontologist for the Compañia de Petroleo Mercedes, S. A., at Monterrey, Mexico.

JOHN F. WEINZIERL, consulting geologist and geophysicist, Petroleum Building, Houston, Texas, addressed the Houston Geological Society on Jan-

uary 20, giving a presentation of Franz Beyschlag's "Geological Map of the Earth."

E. H. WELLS, president of the New Mexico School of Mines, has been appointed state geologist, succeeding C. G. STALEY, who resigned in July to become Hobbs field umpire. Mr. Wells will continue his duties at the school of mines while serving as state geologist.

E. H. MCCOLLOUGH, agent in California for the Amerada Petroleum Corporation, is a member of the board of directors of the Kettleman North Dome Association of California.

G. M. LEES has been appointed chief geologist of the Anglo-Persian Oil Company in place of S. Lister James, who has retired.

J. B. UMPLEBY, geologist and petroleum engineer, announces the removal of his offices from Braniff Building, Oklahoma City, to the City National Bank Building, Norman, Oklahoma.

EVAN JUST, Suite 3300, Pure Oil Building, Chicago, Illinois, has been appointed professor of economic geology for the second semester of 1930-1931 at Lehigh University, Bethlehem, Pennsylvania.

EZEQUIEL ORDÓÑEZ, Abraham Gonzales 79, Mexico City, Mexico, is the author of *Articulos Sueltos*, recently published, which contains "La Baja California. Carta al Señor Presidente de la Republica," "Por qué ha Disminuído la Producción de Petróleo én Mexico?," "Impresiones de un Viaje al Petén, Guatemala," "Preliminar de la Conferencia Sustentada ante el Club de Exploraciones de Mexico sobre La Topografia Glacial del Ixtaccihuatl," "Traces of Ancient Glaciers on Mount Ixtaccihuatl," and "The Proposed Oil Law of Colombia of 1929."

W. T. THOM, JR., professor of Geology, Princeton University, Princeton, New Jersey, addressed the Dallas petroleum geologists on January 30, 1931, on "Research and the Future of Petroleum." Professor Thom is a member of the executive committee of Princeton University International Summer School of Geology and Natural Resources.

A. E. BRAINERD has moved from Ponca City, Oklahoma, to Denver, Colorado, to take charge of the Rocky Mountain and Canadian district for the Continental Oil Company. Mr. Brainerd replaces H. J. PACKARD.

TOM L. COLEMAN, district engineer, U. S. Geological Survey, Muskogee, Oklahoma, is the author of "Repressuring Operations in the Red River Field, Tillman County, Oklahoma," published by permission of the director of the survey.

A. N. MURRAY, of Tulsa University, addressed the Tulsa Geological Society, February 2, 1931, on "Limestones As Oil Reservoirs."

HANS STILLE, of the University of Göttingen, Germany, is spending this month in Texas and Louisiana, examining salt domes.

The officers of the Fort Worth Geological Society for 1931 are: president, FORD BRADISH, of Johnston and Bradish; vice-president, PAUL L. APPLIN, of the Cosden Oil Company; and secretary-treasurer, PAUL M. BUTTERMORE, of the Mid-Kansas Oil and Gas Company.

H. N. SEEVERS, for several years division geologist for the Atlantic Oil Producing Company at Wichita Falls, Texas, is being transferred by that company to the Gulf coastal plain district with headquarters at Corpus Christi, Texas.

MARTIN VAN COUVERING, consulting petroleum engineer, 704 Wright and Callender Building, Los Angeles, California, has an article in the January 30 issue of the *Oil Weekly*, entitled "Engineering Progress in Drilling and Production." He is also the author of an article in the January 31 issue of *The Log* (Engineers Club, Los Angeles), entitled "Historical Sketch of Los Angeles Basin Oil Fields."

GEORGE W. STOSE, geologic map editor of the U. S. Geological Survey, Walter W. BRADLEY, state mineralogist of California, and OLAF P. JENKINS, chief geologist of the California Division of Mines, are arranging coöperative work for the making of a state geologic map of California drawn on the scale of 8 miles to the inch.

ELIOT BLACKWELDER has an article entitled "The Lowering of Playas by Deflation," and GEORGE F. KAY an article, "The Relative Ages of the Iowan and Wisconsin Drift Sheets," in the February number of the *American Journal of Science*.

PARKER D. TRASK has an article on "Sedimentation in the Channel Islands Region, California;" ALBERT O. HAYES, an article on "Structural Geology of the Conception Bay Region, and of the Wabana Iron Ore Deposits of Newfoundland;" and J. VERSLUYS, an article on "Subterranean Water Conditions in the Coastal Regions of the Netherlands," in the January-February number of *Economic Geology*.

HEDWIG T. KNIKER has opened an office in San Angelo, Texas, as micrographer.

PIERRE MARIE TERMIER, one of the most famous geologists of France, died recently at the age of 71 years.

CLARK R. STEINBERGER, geologist for the Ohio Oil Company at Owensboro, Kentucky, was in Mississippi and Alabama in February.

DELMAR GOUIN is district geologist for the Empire Gas and Fuel Company at Roswell, New Mexico.

R. E. DICKERSON, ROBERT PALMER, ROBERT COLLOM, and W. D. CHAWNER of the Atlantic Oil Producing Company, are working in Cuba, with headquarters at Caiberién, Santa Clara Province.

CHARLES T. KIRK, petroleum geologist and engineer, has recently opened offices at 504 Commercial Building, Tulsa, Oklahoma. He is continuing his

consulting practice, being recently interested in the gas territory of Arkansas and eastern Oklahoma, as well as the geology of dam sites and reservoirs.

F. S. Prout is district representative for the Empire Gas and Fuel Company at Tyler, Texas.

R. E. Heitbecker, of the U. S. Bureau of Mines at Shreveport, Louisiana, is preparing a report on the Zwolle oil field.

At the annual meeting of the Alberta Society of Petroleum Geologists, held at Calgary, January 16-17, the following papers were presented: "Foxhills Formation of Southern Alberta" and "Ellis Formation of the Sweetgrass Hills," by J. O. G. Sanderson; "Details of the Bearpaw and Overlying and Underlying Formations in the Lethbridge Area," by Theodore A. Link and A. J. Childerhose; "Stratigraphy of Bearpaw Formation between Lethbridge and Eyremore Districts," by Clare M. Clark; "Sediments of Upper Montana Age in the Mild River Region," by B. F. Hake and C. C. Addison; "Geologic Section on Oldman River between Lethbridge and Taber," by J. O. G. Sanderson and G. E. Wheeler; "Pale and Foremost Beds in the Keho Lake, Champion and Eyremore Districts," and "Stratigraphy of the Paleozoic Sediments of the East Sweetgrass Butte, Montana," by D. L. Powers; "Stratigraphy of the Colorado Formation in the Foothills between Bow and Berland Rivers," by J. B. Webb; "Subsurface Geology of Red Coulee District" and "Subsurface Geology of Spring Coulee Area," by W. S. Yarwood; "Stratigraphy of Morley Formation at Kananaskis Falls, Alberta," by R. Willis; "Possible Oil Structures in Northern Canada due to Post-Pre-Cambrian Intrusions," by A. E. Cameron; "Gas Reserves of Turner Valley," by S. J. Davies. The executives elected to serve in 1931 are: president, J. O. G. Sanderson; vice-president, A. E. Cameron; business manager, E. H. Hunt; secretary-treasurer, J. B. Webb; past-president, B. F. Hake; executive appointed by chair, A. J. Goodman.

J. Volney Lewis announces change of address from 21 State Street, New York, to Administration Building, Burnham Park, Chicago. He has resigned as staff geologist for foreign operations of Gulf Oil Corporation and has joined the staff of A Century of Progress, where he will undertake to organize the work in Geology, Mining and Metallurgy for the Chicago International Exposition in 1933 and to assemble the appropriate exhibits. The plans are being made and work will be carried out with the coöperation of the National Research Council. The keynote of the exposition will be the progress of the century (1833-1933) in science, with emphasis also on the service of science to civilization.

R. A. Steinmayer, of the geological faculty of The Tulane University of Louisiana at New Orleans, addressed the American Institute of Chemical Engineers on "American Salt-Dome Possibilities," at New Orleans, December 10, 1930.

L. P. Teas, geologist with the Humble Oil and Refining Company, gave a paper on "The Hockley Salt-Dome Cap-Rock Contact at Hockley Salt Mine," before the Houston Geological Society, February 10.

F. B. PLUMMER, of the Texas Bureau of Economic Geology at Austin, talked on "Temperature and Chemistry of Woodbine Sand Waters in Relation to Oil Fields," before the Tulsa Geological Society, February 16.

ANDREW C. LAWSON, of Berkeley, California, and Miss Isabelle Collins, of Ottawa, Canada, were married in January.

D. MAX MORGAN, Ponca City, Oklahoma, has resigned from the Wentz Oil Corporation to engage in geophysical prospecting.

C. E. HYDE has returned to Fort Worth after an illness in the East which prevented a tour around the world.

W. H. GEIS, president of the Arrowhead Oil Company, of Los Angeles, is active as general superintendent of the Italo Petroleum Corporation of America.

GEORGE C. BRANNER has estimated that state geological surveys have available, for the fiscal year ending June 30 next, a total of $1,341,859, of which $428,172 is derived from coöperative agreements with institutions and industry. He estimates that petroleum companies in the United States are spending $15,000,000 a year for geological work exclusive of geophysics and core drilling.

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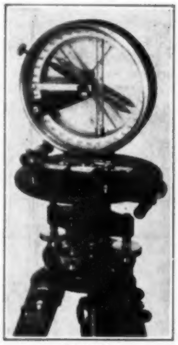

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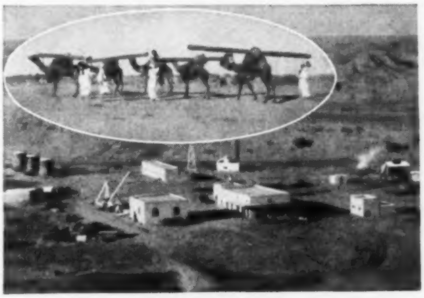

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